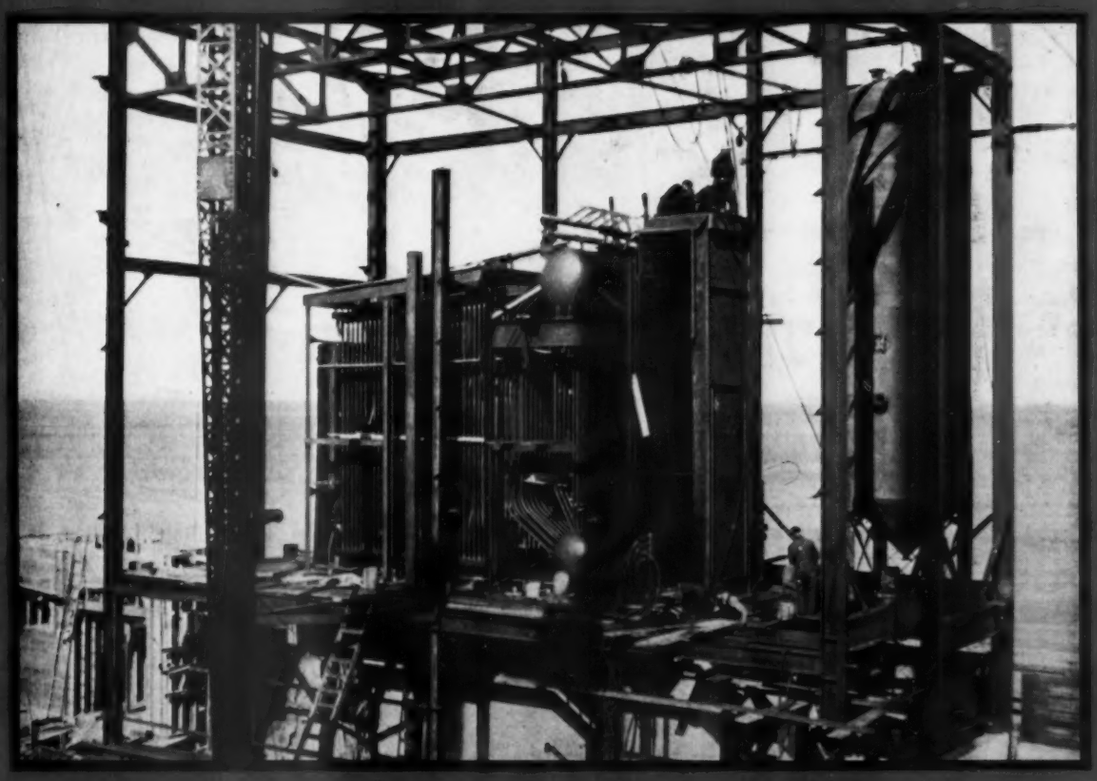
COMBUSTION

DEVOTED TO THE ADVANCEMENT OF STEAM PLANT DESIGN AND OPERATION

Vol. 10, No. 12 JUNE, 1939 25c a copy

Engineering Library

JUN 21 1939



Steam generator being erected at a Michigan paper mill

Furnace Photography

The Recirculation of Boiler Salines

Electric Power Statistics

Cleaning Boiler Heating Surfaces

THOUSANDS OF C-E TRAVELING GRATE STOKERS proved ideal for widely varying applications

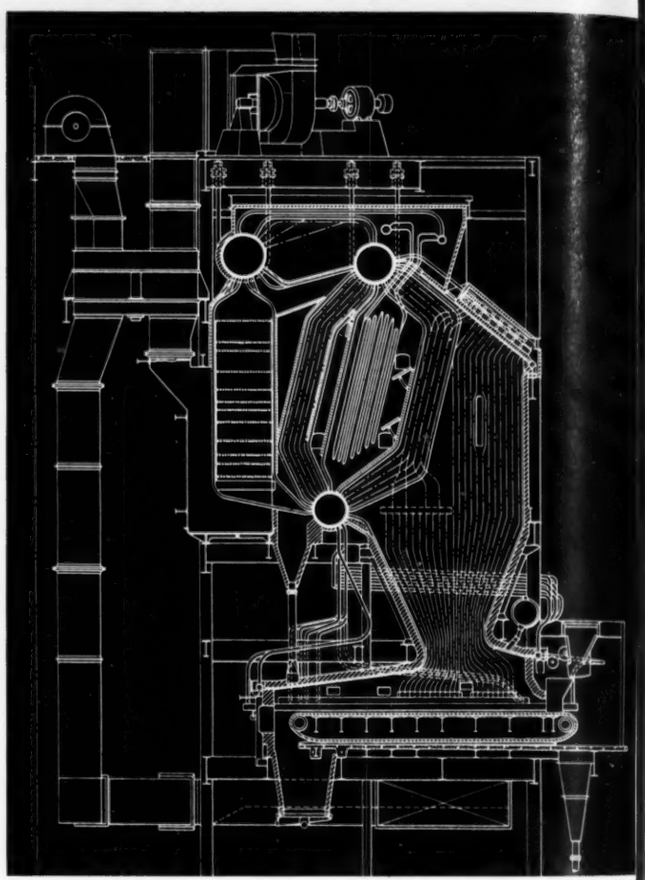
MORE than 22,000,000 sq. ft. of boiler heating surface in thousands of installations throughout the country, are served by C-E Traveling Grate Stokers. They have proved ideal for many fuels including the smaller sizes of anthracite and culm, mid-west bituminous, lignite and coke breeze.

Combustion Engineering produces the most complete line of traveling grates that the market affords. The C-E line comprises several chain grate and bar grate designs, including those widely known under the trade names Coxe and Green.

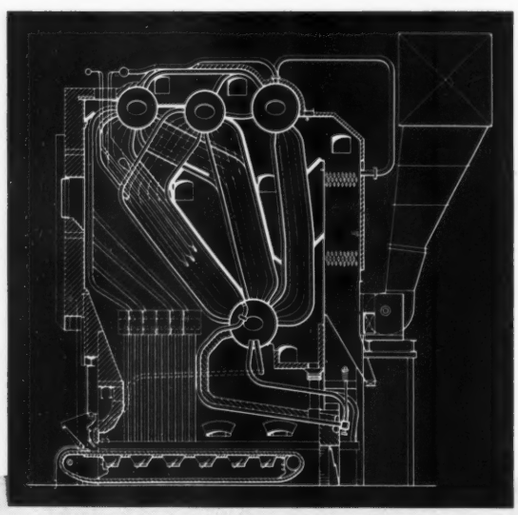
The C-E Chain Grates, which are built for both forced and natural draft applications, are exceptionally well suited to many of the Middle Western coals and have been installed in connection with more than 11,500,000 sq. ft. of boiler heating surface in units ranging in size from 1500 to 20,000 sq. ft.

The C-E Coxe Stoker, a bar grate type, is built only in forced draft designs. It is widely recognized as "the stoker" for burning the smaller sizes of anthracite and has been similarly successful in burning lignite, coke breeze and many free-burning bituminous coals. Nearly 2,400 of these stokers have been installed under boilers having a total heating surface of more than 10,700,000 sq. ft. with a size range similar to that of the chain grates.

When you are studying and evaluating the factors which lead to the selection of fuel-burning equipment, give careful consideration to the advantages of the traveling grate stoker. C-E engineers, by virtue of their extensive experience with these stokers, as well as all types of fuel-burning and steam-generating equipment, are well qualified to assist you with problems in this field. Their advice and recommendations are freely available.

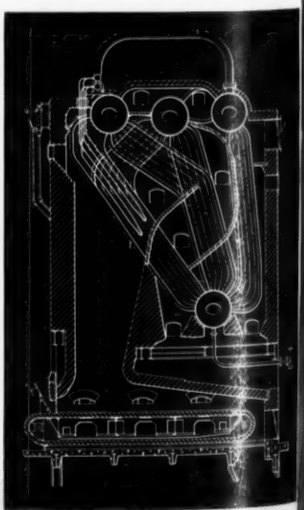


The C-E Chain Grate Stoker above is the largest traveling grate ever built in this country (569 sq ft). It was designed to burn bituminous coal and is equipped with side wall water boxes at the grate line. The furnace walls are water cooled, as are both front and rear arches. Undergrate siftings are removed by steam nozzles. A C-E Bent Tube Boiler, Type VS-3, Elesco Superheater and Economizer, and Ljungstrom Air Heater complete the unit, which is installed at the Omaha Station of the Nebraska Power Co. Capacity—275,000 lb per hr. Design Press.—1350 lb. Total Temp.—915 F.



Left—The C-E Chain Grate shown is of the natural draft type, installed in the Jeffersonville, Indiana, Plant of the Colgate-Palmolive-Peet Company. It is designed to burn mid-western bituminous coal, has full dampered control beneath the grate surface and is equipped with side wall water boxes at the grate line. The furnace has side wall cooling in the throat opening and the full rear arch is of the water-cooled type. The boiler is a C-E Type VA with Elesco Superheater and Fin Tube Economizer. Capacity—35,000 lb per hr. Design Press.—425 lb. Total Temp.—583 F. A new unit, similar in design but larger, has recently been placed in service at this plant.

Right—One of the two C-E Coxe Stokers installed at Stanton Colliery of Glen Alden Coal Company. They are equipped with suitable grate surface to burn anthracite (No. 4 Buck). The furnace has the full rear arch and narrow-throat opening which characterize C-E furnace designs for this class of fuel. The boilers are C-E Type VA, cross baffled and equipped with Elesco Superheaters. Capacity—46,000 lb per hr. Operating Press.—135 lb. Total Temp.—480 F. Over a period of 25 years the Glen Alden Coal Company has purchased 109 Coxe Stokers on 35 contracts.



COMBUSTION ENGINEERING COMPANY, INC

200 Madison Avenue, New York, N.Y. *Canadian Associates, Combustion Engineering Corporation, Ltd., Montreal*

ALL TYPES OF BOILERS, STOKERS, PULVERIZED FUEL SYSTEMS AND HEAT RECOVERY EQUIPMENT

COMBUSTION

DEVOTED TO THE ADVANCEMENT OF STEAM PLANT DESIGN AND OPERATION

VOLUME TEN NUMBER TWELVE

CONTENTS

FOR JUNE 1939

FEATURE ARTICLES

Furnace Photography *by A. A. Markson* 24
The Recirculation of Boiler Salines *by S. M. Sperry* 27
Electric Power Statistics 34
Conveying Oil-Treated Coal 35
Chicago's Air Pollution Survey 36
Cleaning Boiler Heating Surfaces *by F. W. Linaker* 37

EDITORIALS

A Comprehensive Survey 23
Research and Unemployment 23
Designing for Reliability 23

DEPARTMENTS

Steam Engineering Abroad—Largest Traveling-Grate Stoker, Performance at Dalmarnock, 37,500-Kw Radial-Flow Turbines, Combined Grate and Mill Firing, Marine Forced-Circulation Boilers, Turbine in Standby Service 41
General Article Index—(Vol. 10, Nos. 1 to 12) 45
Advertisers in This Issue 48

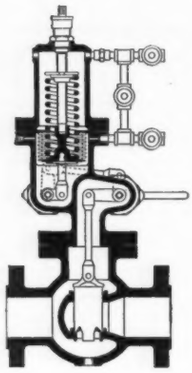
H. STUART ACHESON, *Advertising Manager*
ALFRED D. BLAKE, *Editor*
THOMAS E. HANLEY, *Circulation Manager*

Combustion is published monthly by Combustion Publishing Company, Inc., a subsidiary of Combustion Engineering Company, Inc., 200 Madison Avenue, New York. Frederic A. Schaff, President; Charles McDonough, Vice-President; H. H. Berry, Secretary and Treasurer. It is sent gratis to consulting and designing engineers and those in charge of steam plants from 500 rated boiler horsepower up. To others the subscription rate, including postage, is $2 in the United States, $2.50 in Canada and Great Britain and $3 in other countries. Single copies: 25 cents. Copyright, 1939 by Combustion Publishing Company, Inc. Printed in U. S. A. Publication office, 200 Madison Avenue, New York. Issued the middle of the month of publication.

Member, Controlled Circulation Audit, Inc.

CCA

The COPES Type SDS-2 Pump Governor



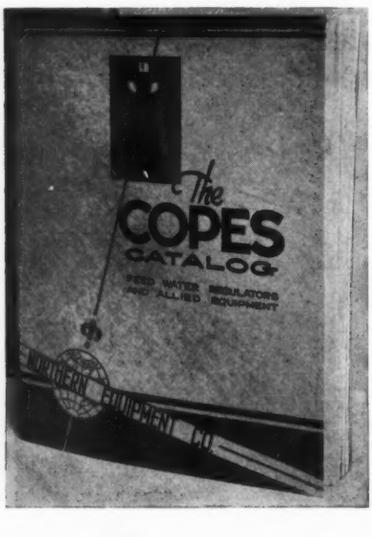
Good feed water regulation begins with a good pump governor, and that is why the COPES Type SDS-2 Governor was developed.

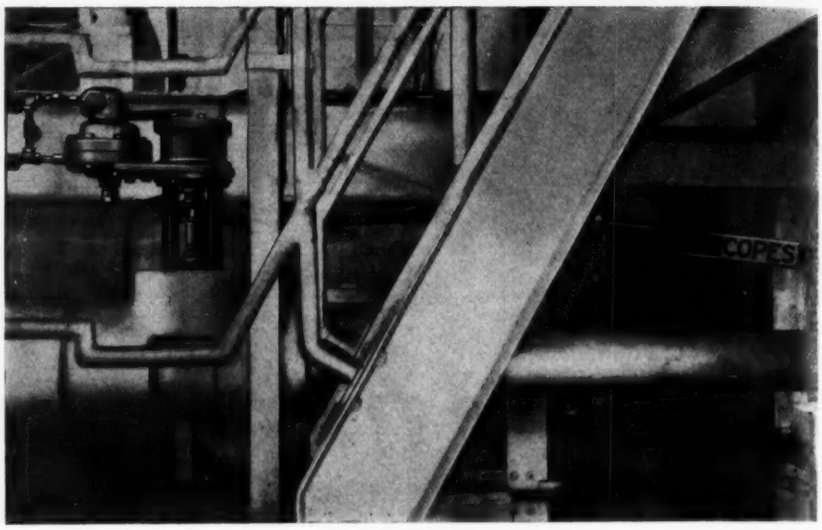
Most of the more than 36,000 COPES Feed Water Regulators in service are used in connection with some type of pump governor. None that we have ever seen has given as uniformly accurate and dependable results as this one. Subjected to the severest service conditions we could find during the last seven years, the record of perfect satisfaction has been 98% plus.

Designed for remote control of the excess feed water pressure. Engineered for the individual installation to assure close regulation. Built for long service life, and delivering it in hundreds of plants.

The Type SDS-2 Governor is described in the COPES Catalog of Feed Water Regulators and Allied Equipment, your most complete reference on feed water regulating equipment. If it is not in your files—

Write for this Catalog





Southern Alkali Corporation

reports boiler water level held within ±½ inch

You can read about this COPES Flowmatic installation in an interesting article—Water Level Control on Southern Alkali Corporation's New Integral Furnace Boiler, by Mr. G. R. Avery, Steam and Power Engineer at the Corpus Christi plant. In regular service, the water level is held within plus or minus ½ inch. On test, the COPES Flowmatic has demonstrated unusual ability to stabilize the water level on rapid, wide load swings. If you are interested in closer boiler water level control, write for Mr. Avery's article. Ask for Bulletin 417.

NORTHERN EQUIPMENT CO., 616 GROVE DRIVE, ERIE, PA.

Feed Water Regulators, Pump Governors, Differential Valves
Liquid Level Controls, Reducing Valves and Desuperheaters

BRANCH PLANTS IN CANADA, ENGLAND, FRANCE, GERMANY, AUSTRIA AND ITALY . . . . REPRESENTATIVES EVERYWHERE

Get closer level control with the

COPES

FEEDS BOILER ACCORDING TO STEAM FLOW•AUTOMATICALLY

FLOWMATIC

★ REGULATOR

EDITORIAL

A Comprehensive Survey

The scope of the present air pollution survey in the Chicago territory eclipses that of any previous investigation of this character. Surveys in other cities have aimed at measuring the smoke, cinder and soot fall in different localities, the atmospheric contamination, influence of the wind, relative contribution by various classes of fuel users, as well as damage to property; but the Chicago plans are still more comprehensive. They include also inquiry into the smoke, cinder and fly ash produced by different fuels, by various methods of firing, by different furnace and boiler arrangements and loadings and by classes of plants. Through analyzing the deposited material an effort will be made to identify the source and to determine what proportion is attributable to non-fuel burning activities. The effect on ultra-violet rays and visible light intensity will be investigated and measurements made of sulphur contamination of the atmosphere. It is hoped that it will be possible to formulate a simple method of fly-ash determinations.

With an approved appropriation of nearly $400,000 for this work, such a program should yield valuable basic information of considerable assistance to various smoke enforcement bodies, plant operators and equipment manufacturers, providing the findings are printed and made available to all parties interested.

Research and Unemployment

"The perfect solution for unemployment," says H. A. Toulmin, Jr., in his forthcoming book on "Patents and the Public Interest," "is found right in the research laboratories and development departments of manufacturing corporations."

Selecting a group of fifteen major industries, created by the efforts of research workers and development engineers, and giving employment to over fifteen million people, the author contrasts this with the billions that have been wasted during the last few years in an effort to provide part time employment at a low wage scale in unproductive work.

Notwithstanding the fact that the number of research laboratories has increased fourfold during the last twenty years there is ample evidence that, generally speaking, we are technically behind rather than technically ahead of present requirements and opportunities.

During periods of scant profits the tendency of many firms has been to curtail, and in some cases to ignore, appropriations for research and development, or to sanction only those necessary to solve immediate problems of design or merchandising. As a temporary expedient this may be excusable, but from the viewpoint of long-range planning it is likely to prove detrimental.

Despite this, it is claimed, on excellent authority, that the results of research carried on during the depression years, by those firms more fortunately situated, would be sufficient, if applied productively, to take up much of the slack in unemployment. That this has not been done, is attributed to hesitancy in making capital investment, due to lack of confidence.

However, if the total annual volume of business is to catch up with the mounting taxation, new industries and new products within existing industries must be created in order to absorb unemployment, increase purchasing power, decrease the taxation incident to relief and once more establish equilibrium between these economic forces.

This has direct bearing upon power requirements of industry and, within the power field itself, upon anticipating and meeting the demands of ever-advancing practice.

During the present month a new batch of technical graduates is going forth into industry. Reports of placements are generally favorable, although it is doubtful that very many will enter the field of research and development. Granted that the individual must be particularly constituted to succeed in such work, the potential needs of this field would appear to offer excellent opportunities for those qualified.

Designing for Reliability

In reading over the *Transactions* of the recent Midwest Power Conference one is impressed with the sound observations of G. G. Post of the Wisconsin Electric Power Company concerning designing for reliability of service. He emphasizes that attention to detail is paramount in order to guard against outage that may cause serious loss of capacity, and that many details are brought to light only through conscientious and intelligent application of operating experience; hence, the desirability of a closely coordinated operating and designing organization in which operating experience is continuously being brought to the attention of the designing engineers.

Obviously, where advance in the application of heat cycles, or other innovations in practice, has proceeded at a faster pace than operating experience, new and unforeseen problems may be introduced. Such pioneering may temporarily sacrifice reliability until the combined efforts of the designing engineer, equipment manufacturer and operator have resulted in a satisfactory solution. For instance, in some of the superimposed installations, where the operators had been accustomed to low-pressure, low-temperature operation, they had to be educated into the more rigid requirements of the higher steam conditions, particularly as to the exclusion of oxygen from the system and closer attention to certain aspects of furnace conditions. Happily, the answers to many of these problems are now known and operation is being adjusted to meet them.

Low overall power costs are dependent as much on reliability and low maintenance as on high thermal efficiency, hence it is essential that economic studies be reviewed in the light of competent operating experience.

FURNACE PHOTOGRAPHY

By A. A. MARKSON, Research Engineer
Consolidated Edison Company of New York

The author offers practical suggestions as to the technique of taking views within a furnace with an ordinary miniature camera, having a metallic bellows, and with various commercially available films. Reproductions of several still pictures are shown in which infra-red film was used. Motion pictures and color photography are also discussed.

A lively and increasing interest is being shown in the photography of power-plant furnaces under operating conditions. Much of this was stimulated by motion pictures shown at the last Annual meeting of the A.S.M.E. The pictures shown at that time by E. G. Bailey were taken of pulverized fuel furnaces on natural color film, and those by W. H. Dargan and his associates were of underfeed stoker furnaces in black and white and on natural color film.[1] Dargan, by using an auxiliary water-cooled optical system, was able to show for the first time the agitation and motion of the fuel in an underfeed stoker by speeding up the scenic action in the ratio of 48 to 1. Those who saw these pictures were as impressed by their technical worth as they were by their novel and purely entertaining aspects. It was apparent that here was a potential tool of good possibilities in the future analysis, design and operation of furnaces and firing equipment. New boiler furnaces will undoubtedly be provided with more observation ports with a view to convenience in making photographic studies.

Fig.1—Fuel bed of traveling grate stoker burning a mixture of anthracite and bituminous coal

It is quite feasible to make furnace photographs which show somewhat more detail than the eye can readily assimilate through a blue glass. These records may be studied at leisure. The amount of detail which the eye and the brain did not register at the time of visual observation may be astonishing in some instances. The use of motion pictures, for instance, offers the possibility of studying the mechanism of slag formation by speeded-up motion much as conventional movies are used to show the growth of a plant extending over weeks in a few minutes on the screen.

Fig. 2—View in ash-pit of dry-bottom furnace

Since the photographic equipment used is relatively cheap and of the amateur variety, the writer has prepared this article with the hope that the simple technique outlined might be of assistance to those who wish to try this sort of photography for themselves. The photographs serving as illustrations were taken by the writer and W. H. Dargan with an ordinary miniature camera on Eastman infra-red film. They are better of course in the original 11 × 14 enlargements which were made from the miniature negatives than in the small halftone reproduction.

Fig. 1 shows the fuel bed of a Coxe stoker burning a mixture of anthracite and bituminous coal. The furnace is equipped with a long rear arch. The stoker is moving from right to left. The zone of cinder emission and the characteristic direction is clearly shown as the coked fuel bed passes over the third air compartment.

Fig. 2 is a view in the ash-pit of a dry-bottom furnace

1 More recent colored motion pictures have been taken in the large pulverized-coal-fired C-E steam generating unit at the Windsor Station of the Ohio Power Company and shown before various groups—EDITOR.

at Kips Bay Station, New York, when the unit was steaming at 325,000 lb per hr. The condition of the refractory is clearly shown.

Fig. 3 was taken at the top of a tangentially-fired unit in the same station. The opposite wall, tube detail,

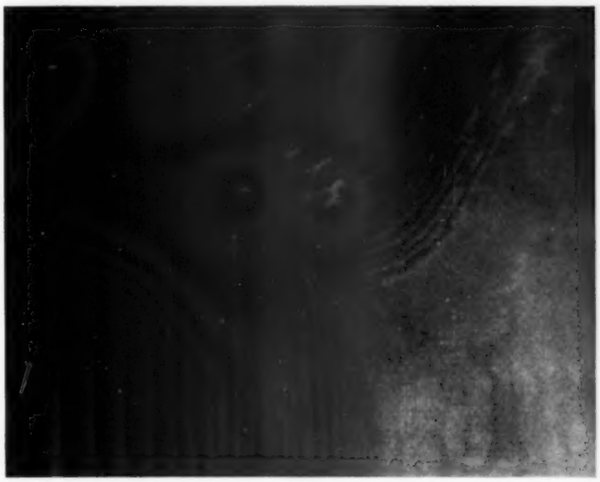


Fig. 3—Near top of furnace in tangentially-fired unit

slag and sponge ash, are all visible. The boiler was steaming at 850,000 lb per hr at the time the picture was taken.

Fig. 4 shows an unusual slag and sponge ash accumulation in a Lopulco fired unit. The wall accumulations are the result of about 40 days' continuous steaming at peak rating. The tube accumulations are sponge ash resembling those of Fig. 3 which do not materially obstruct the gas passages and are removed very readily by water lancing.

Fig. 5 is a view of a tangentially-fired furnace at Kips Bay taken at the burner level above the water screen. The incandescent ash clouds are outlined very clearly. At the right of the picture the three corner burner streams are discernible. It is interesting to see how the flame length decreases progressively from the lowest burner. There are twelve burners in this furnace, three to a corner. The photograph was taken at 400,000 lb of steam per hour generation, the peak load of this boiler being 450,000 lb per hr.

Apparatus and Technique

In the opinion of the writer, it is most desirable for men of operating experience to take such photographs themselves or to supervise their taking. Like X-ray photographs, interpretation means everything. Since practically everyone has some familiarity with photography and since it is probable that the actual making of the pictures will be delegated to some camera enthusiast, the writer will not waste time on discussing standard photographic procedure. Rather, this discussion will be along the lines of outlining the use of available amateur equipment and films for this particular work.

Any good miniature camera having a metallic bellows and a shutter speed of 1–300 sec, or faster, may be used for still photographs. The 35-mm. miniature size is recommended because it seems at present to have a corner on all the different types of emulsions, including infra-red and color film. Automatic focusing is not needed. All metal construction is desirable. The camera should be equipped with a lens hood. Filters are used in much of the black and white work. Dark blue, dark red and near infra-red filters will be invaluable. They should be very high grade, preferably of known transmission characteristics, and of solid glass to withstand a certain amount of heat. Such filter glasses may be obtained through Eimer & Amend, New York City, who will send a complete catalog of Jena glass filters on request. The Eastman Wratten filters are ideal photographically and very readily obtainable but are made of gelatine and will not stand as much abuse as the solid glass variety.

Motion picture equipment from the simple home movie equipment to the semi-professional models may be used. We use a Ciné kodak special 16-mm camera but a good camera having a variety of frame speeds and a single frame device will do very well. With the single frame device an electric timer release is quite indispensable. It may be purchased or home made and should be capable of exposing a frame in intervals from about $^1/_2$ to 10 sec.

Protection of the camera equipment from heat is important. Observation doors should be masked off, except for the taking hole, by asbestos board or transite. For short usage the camera, if all metal, can stand a surprising amount of radiant heat if wrapped in asbestos paper.

A heat-absorbing water-cooled cell will be useful in protecting the camera for longer periods. It may be so constructed as to allow a flow of cooling water between closely spaced plate glasses. In some of our work we use a water-cooled auxiliary optical system as shown in Fig. 6 which can be moved into the furnace itself whereas the camera is protected. This optical system was made by the Bausch & Lomb Optical Company. It is a nice

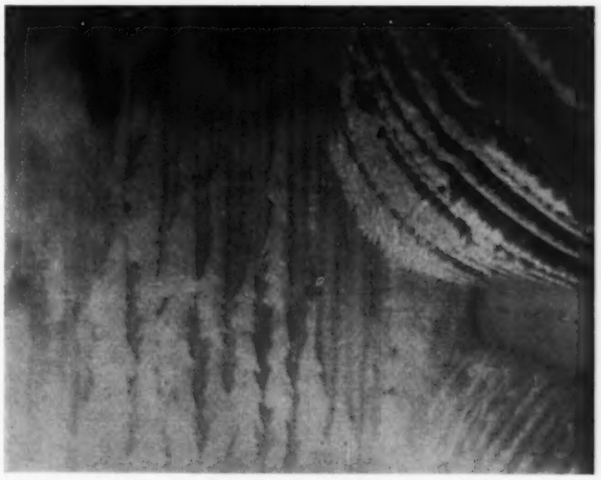


Fig. 4—Slag and sponge ash accumulations after 40 days' continuous operation

refinement in making motion pictures of parts of the furnace otherwise not accessible.

A good photoelectric exposure meter completes the basic apparatus. It will be found that the light intensity in certain parts of the furnace will be much too great for the standard meters. A diaphragm capable of reducing the reading of the meter by about 10 to 1 is readily cut from a piece of metal and checked against light from the sky or some steady high intensity light. This is very

crude but, as will be seen later, is used in a sufficiently accurate manner.

Emulsions

The 35-mm miniature films are available in blue sensitive (color blind), yellow sensitive (orthochromatic), red sensitive (panchromatic) and infra-red sensitive films. They are also available in Kodachrome and Dufay color. All have some useful field of application. The writer has found that the Eastman infra-red film has certain advantages in the water-cooled furnace. The rationale of photographing in the extreme red in the furnace is qualitatively simple. The two fundamental laws of radiation are that the amount of radiation between black bodies depends on the fourth powers of the absolute temperatures and that the peak intensity wave lengths of the radiation depend simply on the absolute temperature. These laws are the theoretical bases for optical pyrometers. Thus, though the intensity of the radiation from a furnace is very high, the color temperature is quite low with respect to blue-sensitive film. As a more red-sensitive film is used it becomes possible to screen or filter out the blue and green light of the furnace which is only abundant in the flame itself and contributes to haze. One may then expose for those objects which are richest in heat radiation wave lengths, such as the tubes, without overexposing the brightest parts such as the flame particles, slag and refractories. The result is a photograph capable of showing considerable detail. Research workers will be interested in the use of Eastman spectrographic plates some of which extend far in the infra-red, but the standard Eastman infra-red film is quite satisfactory for making good photographs.

Kodachrome film may be used with the same purpose in mind, since it is color sensitive. Naturally no true natural color rendition of the furnace could be satisfactory for it would have much the same glare as the original. On the other hand, photographing with ordinary blue-sensitive film, with or without blue filters, may have decided value. Stoker photographs made in this way show the burning lanes in the fuel bed much as though one were viewing a fire in a blacksmith's forge. Contrast may be increased in this manner.

Fig. 5—At burner level of tangentially-fired furnace

Motion-picture workers will probably start with the use of amateur reversible film. From that it is but a step to the more flexible negative-positive process. The 16-mm infra-red motion-picture film must be handled this way.

A system for working out exposures similar to that employed by the writer will be found useful. It consists of taking several dozen exposures, using the desired taking filters and films, varying the exposures systematically and noting the reading of the photoelectric exposure meter. The test exposures should be made in as many different zones of brightness as possible. Upon development, all the satisfactory negatives should be classified. The amount of light which affected the film

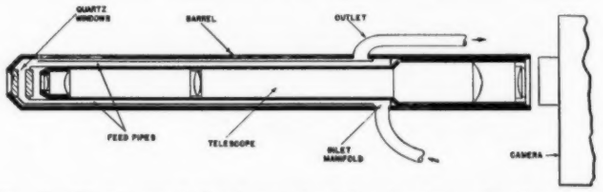


Fig. 6—Water-cooled telescopic tube for introduction into furnace

is inversely proportional to the square of the aperture or f number and directly proportional to the time of exposure. This product, t/f^2, for all satisfactory negatives may be tabulated. These values are plotted against the exposure meter readings corresponding to each value. For example, an exposure of $^1/_{500}$ sec at f.8 gave a satisfactory negative. The exposure meter read 600. The light product t/f^2 is $\frac{1}{500 \times 64}$. Plot this value, or more conveniently its reciprocal, against 600. A smooth curve is drawn through the points and thereafter may be used with the meter as an exposure guide. If the curve is a straight line it may be dispensed with, for obviously any exposure on the curve may be set on the exposure meter calculator dial and an apparent film speed corresponding to this obtained. Thus, using the particular model of Weston meter available to the writer and a red filter corresponding to Wratten A, Eastman infra-red film had a speed of about 40 referred to the normal dial-setting arrow. With an opaque infra-red filter, the apparent speed was 1. In general, the film speeds given for daylight work do not hold because the color temperature of a furnace is low compared with daylight but the radiation intensity is extremely high. The latitude of commercial film is sufficient to overcome any lack of ultra-scientific precision in the methods outlined. Since there is no ordinary standard by which to judge the pictures, especially colored ones, except possibly vision through a blue fire glass, the results produced should be judged by the amount of observable and useful detail produced.

In conclusion, reference may be made to the following excellent publications of the Eastman Kodak Company which give lucid and simple discussions of photographic theory and filter and emulsion data:

The Fundamentals of Photography
The Photography of Colored Objects
Wratten Light Filters
Eastman Spectrographic Plates

Furthermore, the Research Department of that company is always glad to be of help in aiding those engaged in scientific photographic work.

The Recirculation of Boiler Salines

By S. M. SPERRY

The Utility Management Corp.

Reading, Pa.

By the recirculation of from 1 to 2 per cent of the boiler water the hydrogen ion concentration of the boiler feedwater is corrected for the protection of economizers, feed pumps and feed piping without the introduction of additional chemicals. The results of laboratory studies are given and the experiences of a number of modern stations employing this procedure are reviewed.

THE many advances in the art of water conditioning during the past twenty-five years have successfully eliminated boiler scale formation and restricted corrosion of steam generating equipment and its auxiliaries to a marked degree. Experience, however, has revealed vital points particularly in the modern high-pressure and high-temperature stations which do not receive complete protection under existing conditions.

Both steel-tube economizers and boiler-feed pumps have revealed a susceptibility to attack which is attributable to feedwater conditions previously accepted as satisfactory and considered unlikely to cause damage. Economizer-tube corrosion and boiler-feed pump maintenance in modern high-pressure stations have brought to light the fact that there has been some oversight in the consideration of protection for these important pieces of station equipment. It is the purpose of the writer to describe a method, which has been successfully applied in a number of steam generating stations, for the protection of feed pumps, piping and economizers. This treatment is essentially a process of correction of the hydrogen-ion concentration (pH value) of the boiler feedwater which does not involve the introduction of additional chemicals to the water in the system. Our practice calls for the recirculation of a small percentage of boiler salines, drawing them from a boiler drum and introducing the recirculated water to the feedwater system at the deaerating heater storage tank.

This use of boiler salines as a chemical reagent in recirculation differs from its predecessors, which attempted large scale reclamation of the chemical constituents of boiler water. These other methods have been worked out both in this country and abroad, and are embodied in such processes as the Neckar and Kestner Systems.

Survey of Conditions

Summaries of feedwater analyses reported to our engineering department revealed that approximately one-half of the newer, better equipped high-pressure stations were handling feedwater with a pH value below 7.0. Altogether, there were approximately 20 steam boiler plants in which trouble might be expected to develop in the feedwater systems. In some cases, gradual corrosion was known to be progressing; in others, boiler-feed pump maintenance was excessive and doubts as to the efficacy of the protective method being used existed in still other stations. Our summaries showed that less than one-third of the stations were employing boiler feedwater which was sufficiently alkaline to render corrosion unlikely.

Confirmation of these findings was obtained by studying the analytical reports from our central laboratory to these same stations. It was apparent that consistently higher iron concentrations were found in the feedwater than could be expected from the quantity of treated makeup water added to the systems. The low pH values reported were confirmed and it became apparent that all analytical evidences pointed to the existence of a gradual corrosion of the ferrous metals in contact with the heated feedwater. Station maintenance, in some instances, revealed the progress of this condition, and it became evident that measures should be taken to overcome the difficulty.

The simplest available avenue of approach lay in the elimination of the apparent acidity and correspondingly increasing the pH value of the feedwater.

Methods of Feedwater pH Correction

Either the continuous addition of an alkaline chemical reagent or the recirculation of a part of the boiler salines may be employed to correct the pH value of the feedwater. The continuous addition of an alkali will require the addition of heat exchangers to the station equipment in order to reclaim the heat in the large amount of blowdown necessary to avoid building up the alkalinity concentration of the salines in excess of that found by good practice. Further, this method will render necessary a carefully adjusted and reliable feeding device to control the alkali fed. The alternate method, that of recirculation, also involves a slight thermodynamic loss in that some heat is taken from the boiler and introduced to the feedwater, thereby reducing, slightly, the bled or auxiliary exhaust steam which can be absorbed by the feedwater. This process does not add any additional chemical reagent to the salines and does not result in a rapid concentration of alkaline material in the boiler, hence normal blowdown conditions are not affected. Any reduction in boiler capacity caused by the recirculation

of a few per cent of the boiler water will certainly be negligible. Control of the recirculated water may be effected by orifices or better by calibrated valves.

In one station, we have found it desirable to combine recirculation with the continuous introduction of caustic soda to the feedwater in order to obtain the desired feedwater condition in the most economical manner.

Recirculation has been in practice in a number of stations for a period of years and has been very effective. The introduction of salines to the heater storage tank brings about a thorough mixing action and provides protection to the storage tank and all other equipment between the deaerating heater and the boiler. Since a small amount of sulphite will be contained in the boiler water used, it is desirable to mix this with deaerated water in order to conserve the sulphite for effective chemical deaeration and remove the last traces of dissolved oxygen.

Underlying Theory

Research laboratories have demonstrated the fact that the point of minimum solubility of iron in distilled water occurs at a pH of 9.6. Recirculation rarely brings the pH rise to this point nor is it desirable to maintain such a high pH value, but by approaching this point, we reduce the tendency of iron to go into solution.

Generally, boiler salines contain sodium hydroxide derived from the treatment processes or the decomposition of sodium carbonate in the feedwater. Sodium hydroxide is a highly effective agent for increasing the pH value of a water, particularly in the case of such unbuffered waters as condensate. The addition of salines to a feedwater renders the latter more alkaline and less likely to take ferrous metal ions into solution. Further, under more alkaline conditions, dissolved oxygen will be less effective as a corroding agent than in a neutral or acidic medium.

It is our practice to add, continuously, small amounts of sodium sulphite to the feedwater for the purpose of combining chemically with any traces of dissolved oxygen which may pass the deaerating heater. This treatment is wholly supplementary to the mechanical deaeration which is called upon to remove as much of the dissolved oxygen as the limitations of the process will permit. By the introduction of salines into the feedwater, additional sodium sulphite becomes available from the excess sulphite concentration in the boiler water and there is less possibility of dissolved oxygen gaining access to the boiler.

The practice of recirculation tends to improve feedwater conditions in the four following ways:

A. Higher feedwater hydrogen ion concentration (pH value).

B. Introduction of phenolphthalein alkalinity to feedwater.

C. Increased total alkalinity content of feedwater.

D. Greater sodium sulphite concentration in boiler feedwater.

Collection of Salines

It is desirable to employ clear salines containing a minimum of suspended matter in feedwater pH correction. The proper point of take-off of salines may be selected by the analysis of samples taken from the various boiler drums. It is better to employ concentrated salines rather than a mixture of salines and feedwater which may appear in sample lines from some of the drums; a lesser quantity of the concentrated water will be needed and the smaller the amount of suspended matter present, the less will be the likelihood of erosion or clogged orifices, control valves and other equipment.

Salines for recirculation are preferably collected solely for this purpose from a header extending the length of the boiler drum and perforated with holes so located that they are not impinged upon by streams of steam and water emerging from circulating tubes of the boiler. In a station where recirculation was supplemented by the continuous addition of caustic soda, an attempt was made to split the stream of water from such a header recirculating part of it and passing the rest to waste through heat exchangers. This system was unstable and necessitated frequent readjustments of both branches in order to maintain the desired conditions. It is preferable to keep the two systems wholly separate as less attention will be needed than where the dual arrangement is followed.

It is essential that the differences between recirculation and boiler blowoff be clearly borne in mind. Nothing is lost from a system in which recirculation is practiced. The concentrated salines taken from a boiler are merely diluted by the feedwater and returned to their source. Any solids originally present in the feedwater will tend to concentrate in exactly the same manner as previously noted prior to the practice of recirculation. A reduction in solids in the salines must be accomplished by the separate practice of blowing off the boiler.

Limitations

As in all forms of water treatment, there are limits to the application of recirculation. The economic factors are discussed elsewhere but it is apparent that in cases where one or two per cent of the salines are recirculated, the general effect will be beneficial, the equipment relatively inexpensive and comparatively little attention will be needed for operation. Where the feedwater is principally condensate, to which fully softened water is added and which contains small amounts of condenser leakage, we have an unbuffered solution, the pH of which will change rapidly with the addition of a strong electrolyte such as the sodium hydroxide contained in boiler water.

A limiting case is encountered where large amounts of raw or treated water makeup or condenser leakage enters the condensate. We no longer have an unbuffered solution and pH changes are not large with the addition of small caustic soda dosages. It is then necessary to add large quantities of salines to effect the desired pH correction. To avoid recirculating large amounts of boiler salines, a caustic soda solution may be added continuously to the feedwater. Under such circumstances the alkalinity of the boiler water rises rapidly and, to control it satisfactorily, a continuous blowoff is necessary. To prevent the wastage of large amounts of heat in such a case, heat exchangers must be installed. Cases of this type are comparatively rare and necessitate a complete analysis to determine whether the capital cost will be justified.

As pointed out previously, a pH value of 9.6 would be preferable for the protection of the ferrous metals in the system. The characteristics of the bronzes employed in boiler feed pump impeller construction, however, limit

the maximum pH to 9.0 and set the desired average at 8.6. Although feedwater treated by recirculation will not be at the optimum pH value, it is apparent that such water will have less tendency to corrode iron than a feedwater at pH 6.6.

The additional water which must be pumped to the boilers will increase the work done by the boiler-feed pumps and will correspondingly raise the energy consumption of the pumps. This increase is relatively small; in one case, involving a 55,000-kw station at which approximately 1 per cent of recirculation is employed, the horsepower consumed by the boiler-feed pumps was increased by approximately 40 horsepower.

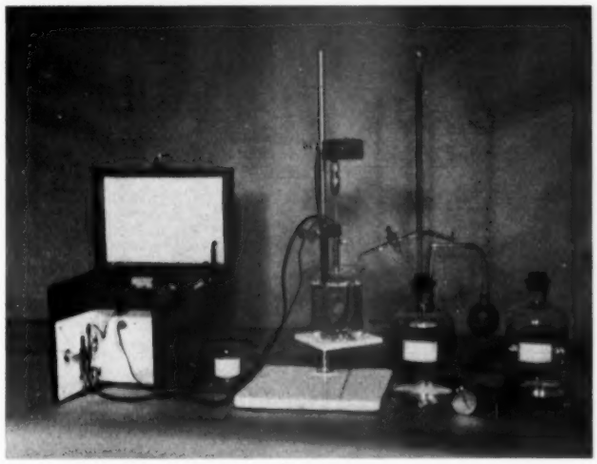


Fig. 1—Apparatus for laboratory study of recirculation

Under certain conditions, stations which employ desuperheaters supplied with boiler feedwater, may encounter difficulties from the deposition of soluble solids upon turbine blades and nozzles. Where not severe, it has been found safe to rely upon occasional washing of the turbine with saturated steam to maintain the surfaces in a clean condition. If deposits tend to accumulate too rapidly or are too hard to be removed by washing, it may be necessary to employ a special pump to deliver condensate to the desuperheater.

In a plant in which phosphate is added to the feedwater at the deaerating heater, it may appear that recirculation of boiler salines might cause precipitation of phosphate sludge in the feed pump, closed heaters and economizers. Experience at a station which employs a primary phosphate treatment and at which considerable work has been done to establish the limiting pH value below which suspended matter does not appear in the feedwater, reveals that a pH value of 8.8 will provide freedom from deposition of phosphate sludge. Since the recommended average pH value of feedwater treated by recirculation is 8.6 with a maximum of not more than 9.0, it appears that there is not much danger of trouble from this source.

Each station must be considered as an individual problem when recirculation is proposed. It is necessary to review carefully the whole of the cycle involved, estimate the effect of the addition of salines to the feedwater upon the functioning of each piece of equipment and determine the changes, if any, which will be required in the station heat balance. This study is necessary, if all the factors involved are to be considered and allowed for, prior to employing recirculation.

Laboratory Study of Recirculation

As a result of considerable study of the problem both in the laboratory and in the field, we assembled the equipment shown in Fig. 1, which consists of the following items:

Electrometric pH set
Set of permanent foundation-pen electrodes
Burette titration stand
Buffer solution pH 7.0
Motor-driven agitator
1000-ml Pyrex clear bottle
600-ml short form beaker
10-ml automatic burette
Centrigrade thermometer 0–100 C.

It will be noted that an electrometric pH apparatus should be used in test work. Attempts to perform this work by means of colorimetric indicators revealed that they lacked the flexibility for studying the wide pH range covered in the investigations. Colorimetric equipment has proven to be satisfactory for the control and check determinations of pH that are made after the actual curve has been established showing the relationship between pH and the percentage of boiler salines added to feedwater.

The laboratory procedure followed in studying the individual cases is as follows:

Place a 500-ml sample of freshly drawn boiler feedwater in the 600-ml beaker and insert the stirring apparatus. Then put in position the automatic burette

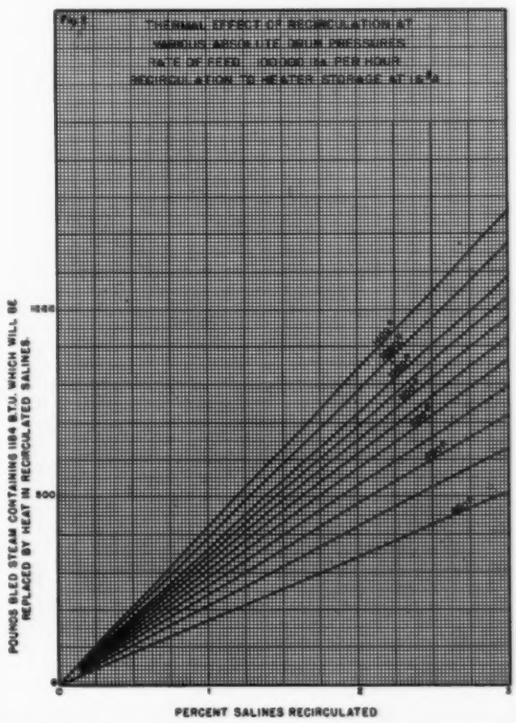

POUNDS BLED STEAM CONTAINING 1164 B.T.U. WHICH WILL BE REPLACED BY HEAT IN RECIRCULATED SALINES
PERCENT SALINES RECIRCULATED

Fig. 2—Thermal effect of recirculation at various absolute drum pressures with rate of feed, 100,000 lb per hr and recirculation to heater storage at 16 lb abs

and the 1000-ml Pyrex bottle which serves as a reservoir for the salines to be used in the titration. The electrodes are then immersed in the sample and the stirrer placed in operation. The stirring should consist of a gentle agitation which will rapidly distribute small additions of salines through the bulk of the feedwater. The salines

should be added 1 ml at a time and the pH determined after each addition until the increase drops to less than 0.1 pH unit at which time the quantity of salines added may be increased to 2 ml. Further increases may be made when the pH increment decreases to less than the suggested 0.1 pH unit.

The results of the titration may be plotted with an auxiliary axis showing the percentage of the mixture comprising boiler salines as illustrated by the curves entitled, "Rise of pH of Feedwater from Recirculation of Salines," (Fig. 4). This feature, which permits the estimation of the approximate percentage of recirculation necessary to obtain a predetermined rise in boiler feed pH, is further discussed in connection with the curves.

Thermal Effect of Recirculation at Various Absolute Drum Pressures

These curves, Fig. 2, indicate the extent of the changes in the station heat balance brought about by recirculating boiler salines to the feedwater. The cases covered illustrate the amounts of bled steam at 1184 Btu per lb which are replaced at the open heater by the available heat in various percentages of boiler salines recirculated from boiler drum pressures ranging from 200 to 1400 lb per sq in. absolute. For convenience, it is assumed in all cases that the feedwater flow is 100,000 lb per hour and the absolute pressure in the deaerating heater is 16 lb per sq in. absolute.

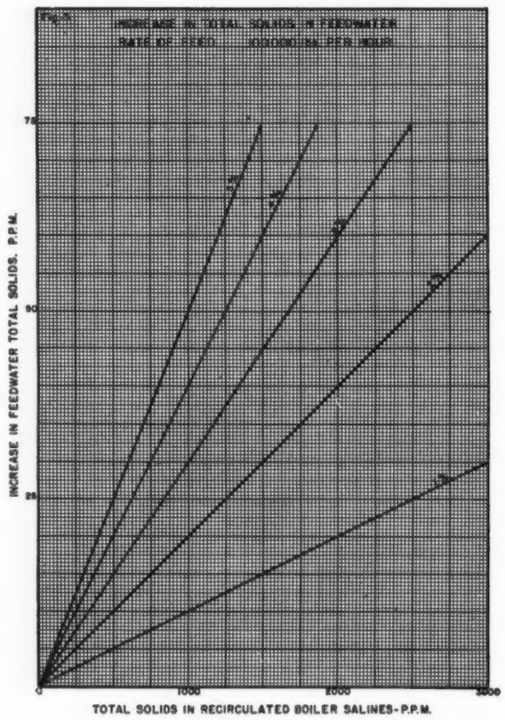


Fig. 3—Increase in total solids in feedwater with rate of feed 100,000 lb per hr

Where different feed rates are encountered, the results taken from the curves may readily be modified as the quantity of salines recirculated at a given rate per cent will remain directly proportional to the flow of feedwater.

If bled steam of a different heat content than 1184 Btu per pound or auxiliary exhaust steam is employed for feedwater heating at the open or deaerating heater, the amount of such steam that will be replaced may be estimated by the use of a correction factor. First, from the chart, estimate the amount of 1184-Btu steam which would be replaced, then multiply this weight by the factor $\frac{1000}{X-1184}$ where X represents the actual Btu content of the steam to be replaced. Minor variations such as

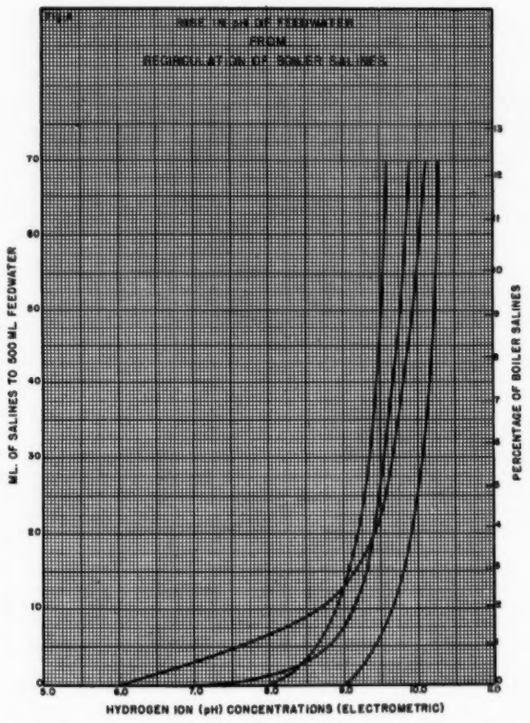


Fig. 4—Rise in pH of feedwater from recirculation of boiler salines

differences in deaerating heater pressure may be neglected in rough estimates based on the chart.

Increase in Total Solids in Feedwater

For convenience in estimating the rise in solids concentration in the feedwater resulting from recirculation, the curves shown in Fig. 3 have been included. The salines considered range as high as 3000 ppm which will include the majority of the cases encountered in practice.

It must be clearly borne in mind that the values shown are increases over the total solids concentrations originally present in the feedwater prior to the introduction of the salines. As may be readily seen by reference to the curves, the increases are minor in the majority of cases where small percentages of recirculation are employed.

With a constant rate of flow of recirculated salines, a rapid increase in total solids in the feedwater will occur with a sharp decrease in load. This might be expected to cause difficulty in a station employing steam washers. We have had occasion to check this point in the case of a central station employing approximately 1 per cent of recirculation of salines containing 1500 ppm of total solids. Sharp reductions in load have never resulted in any difficulties although an appreciable rise in the solids content of the steam passing through the steam washer might reasonably be expected. No evidences of the presence of excessive moisture or solids in the saturated steam have been noticed nor have inspections revealed any deposits in the superheaters.

Rise in pH of Feedwater from Recirculation of Boiler Salines

A series of selected curves, Fig. 4, show laboratory results upon four different feedwaters of different initial pH values, each treated with salines of different concentrations. Three of the four stations covered now

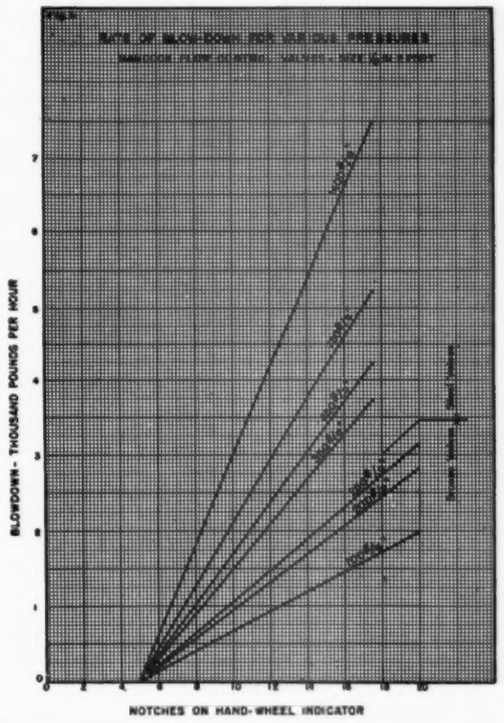


Fig. 5—Rate of blowdown for various pressures with "Flo-control" valves, 1/2 in., 2-port

practice recirculation, and the last one has an initially high feedwater pH as the result of the necessity of using a large proportion of hot lime-soda process makeup water. These curves illustrate the wide applicability of the method and demonstrate that appreciable improvement may be obtained with a small amount of recirculated salines despite an initially low feedwater pH. The experience of several stations over a period of years has demonstrated the feasibility of the process.

Rate of Blowdown for Various Pressures

Several installations using Hancock "Flocontrol" valves have demonstrated their suitability for the purpose of flow regulation. The construction of these valves embodies the use of "V" ports, the flow through which is directly proportional to the travel of the valve steam from the beginning of flow to full opening. A micrometer adjustment is provided, which, in conjunction with the straight-line flow characteristic, makes it possible to closely control the quantity of salines recirculated and makes available the desired flow quickly and accurately after boiler load changes or other plant adjustments.

When installing such valves, it must be borne in mind that they are control devices which should be readily accessible, that is, near the operating floor. If such a location is not made, there may be a tendency to overlook desirable adjustments and countenance poor regulation particularly at times of marked load change.

The adjustments of these valves should be correlated with periodic boiler feedwater pH values which should be taken at regular intervals. Our recommended practice calls for feedwater pH determinations at two-hour intervals continuously. In this manner the greatest benefit will be obtained from both the valves and the pH readings. The rate of blowdown for various pressures when using such valves is given in Fig. 5.

Variation in Hydrogen Ion Concentration (pH Value) of Feedwater as Load Changes

The curves, Fig. 6, illustrate the changes in feedwater pH value encountered in the high-pressure section of a steam generating station. The plant here considered comprises three 410-lb pressure boilers and a 30,000-kw turbine-generator. The pH values of the feedwater were obtained at two-hour intervals throughout the day before and after the practice of recirculation was inaugurated. The load curve of the machine is typical of the conditions encountered on each of the days chosen. The makeup for this station averages less than 1 per cent, only condensate and evaporator distillate being employed as boiler feedwater.

A survey of the curves reveals that prior to recirculation, the tendency to produce condensate at a low pH value was greatest at times of low load. This appears to indicate that carbon dioxide is liberated in the system at

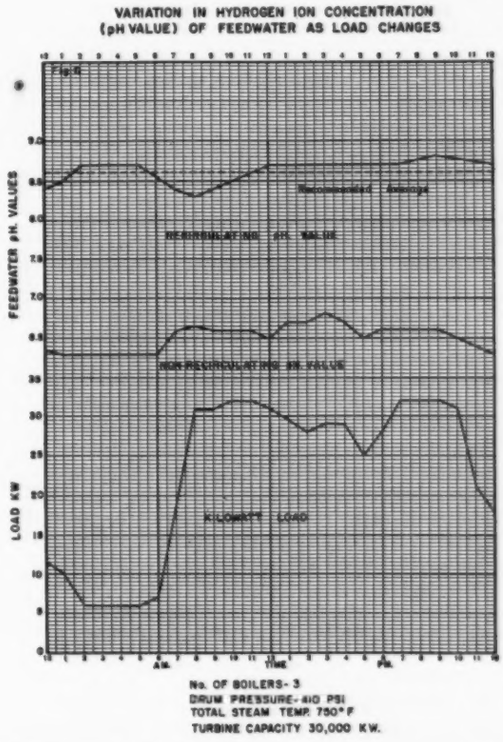


Fig. 6—Variation in hydrogen ion concentration (pH value) of feedwater as load changes

3 boilers; 410 lb per sq in. drum pressure; 750 F total steam temperature; turbine capacity 30,000 kw

a constant rate regardless of the steaming load on the boilers.

The recirculation was controlled by manual operation of the Flocontrol valves at infrequent intervals. Although pH values shown in this curve are slightly higher than recommended, conditions were tolerably stable throughout the day and relatively little attention was needed to effect the desired control. It is of note that

less than 1 per cent of boiler water was being recirculated at any time throughout the day covered.

To illustrate further the effects of pH correction, the following table, entitled, "Typical Analyses and Condi-

TYPICAL ANALYSES AND CONDITIONS RESULTING FROM RECIRCULATION

Station	Analysis	P-Alk. $CaCO_3$	M-Alk. $CaCO_3$	Chlorides Cl	Chlorides NaCl	Hardness $CaCO_3$	Sulphite Na_2SO_3	H-Ion pH	Phosphate PO_4	Sulphate Na_2SO_4	Total Solids
1	A	0	3	3	..	0	..	6.7	..	..	7.0
	B	0	3	3	..	0	..	6.7	..	..	7.0
	C	3	8	3.5	..	0	0.4	8.8	..	..	16.0
	D	104	168	..	60	0	38	10.9	34	568	867
2	A	0	4	4	..	0	..	5.5	..	..	10.0
	B	0	16	7	..	0	..	7.3	..	..	27.6
	C	4	18	4	..	0	0.2	8.6	..	..	48
	D	176	200	..	40	0	8	11.2	11	710	1000
3	A	0	3	2.4	..	0	..	6.7	..	..	8.0
	B	0	5	1.4	..	0	..	6.9	..	..	7.3
	C	5	13	3.4	..	0	0.6	8.4	..	..	14
	D	180	250	..	172	0	42	11.1	18	696	1200
4	A	0	0.5	1.3	..	0	..	6.8	..	..	3.6
	B	0	1.0	1.5	..	0	..	7.0	..	..	4.5
	C	3	5.5	1.0	..	0	0.45	8.6	..	..	14
	D	104	136	..	8	0	21	11.1	32	404	573

A—Typical analysis of condensate
B—Boiler feedwater—No recirculation
C—Boiler feedwater with recirculation
D—Typical analysis of boiler salines

STATION NO. 1—Analyses A and B cover condensate and boiler feedwater conditions before the inauguration of recirculation of salines at a modern 650-lb station. Considerable boiler-feed pump maintenance in the first two years of operation was finally attributed to the low pH of the feedwater by the pump manufacturer and to prevent the recurrence of the failures, pH correction was started. Analysis C indicates the quality of the present feedwater and a characteristic boiler water analysis has been included for reference. The resultant effect upon the feedwater of the addition of a small amount of salines is about what may be expected, a large increase in pH value, and a small increase in total alkalinity and the appearance of some P alkalinity. Recent reports indicate that such results are obtained with about 0.5 per cent recirculation.

STATION NO. 2—This 400-lb station introduced pH correction of the feedwater about 1935. Characteristic analyses are shown of the condensate and feedwater with and without correction and a typical boiler water analysis. Orifices have been used to control the amount of salines admitted to the heater at this station for several years and, although the changing of orifices to accommodate load variations is convenient, the practice of recirculation has obviated feed pump troubles.

STATION NO. 3—This is a 650-lb station recently placed in operation in which provision for recirculation was incorporated in the original design. The feedwater consists of condensate and evaporated makeup which must be treated to render it less likely to attack metals with which it comes in contact. All steam produced is washed by the feedwater entering the boilers and the saturated steam has been found to be satisfactory even at times of changing load. It is interesting to note that the purity of the condensate is so high that merely a trace of salines is sufficient to bring about the desired correction.

STATION NO. 4—This is a recently installed 650-lb boiler plant augmenting the steam production facilities of an older steam station. During design conferences, the desirability of recirculation was discussed but the installation was deferred until after the new units were in operation. Shortly after the new boilers were placed in service, the chemist at the station reported that the iron content of the water showed an increase in passing through the heater. It was agreed that the most satisfactory means of eliminating this condition was the recirculation of a small amount of boiler salines. Recent analyses indicate that heater corrosion has been eliminated and that the feedwater pH is being maintained at a satisfactory value.

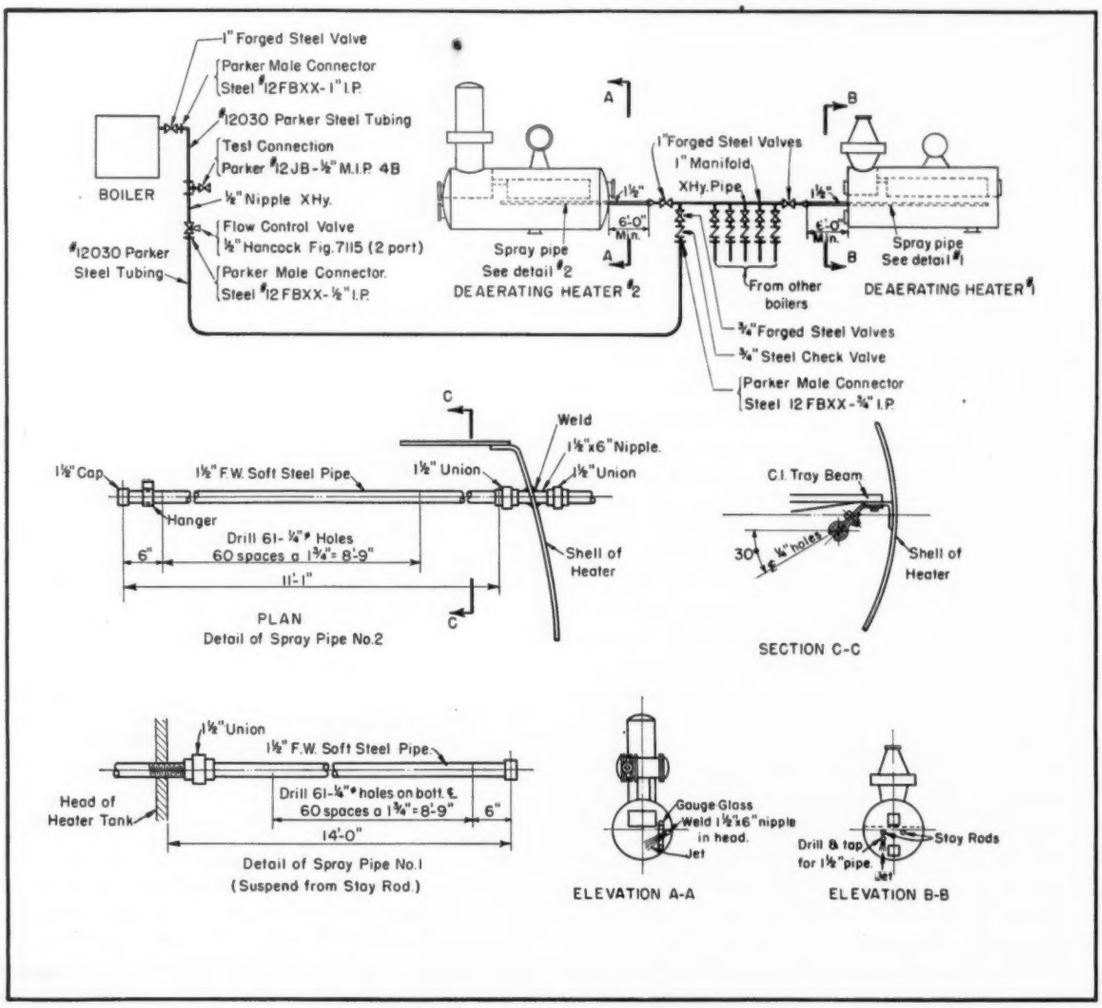


Fig. 7—Schematic diagram of recirculation

tions Resulting from Recirculation," has been included. This covers findings at four stations which employ recirculation. Each set of analyses is described and the station conditions pertaining to the problems are outlined in explanatory notes which follow the table.

Schematic Diagram of Recirculation

Fig. 7 shows the elements of the piping and fittings employed to bring about recirculation and provide a positive control of the process. The drawing illustrates the actual installation made in a large central station. The arrangement of the principal parts of the station, which are involved, is plainly shown by this diagram.

To reduce the noise which would occur if a small size pipe were used to introduce the salines and flashed steam to the heater, a larger size run has been inserted in this line adjacent to the storage tank.

In the steam space of the heater storage tank a distributor has been erected. This is merely a perforated pipe of sufficient length to uniformly distribute salines in such a manner as to produce a minimum of disturbance in the stored water. The arrangement shown is one which has been successfully applied; another lies in placing the manifold across the space below the deaerating trays and above the overflow level in the storage tank.

A. G. Christie Honored

At the Sixty-Seventh Annual Commencement Exercises of Stevens Institute of Technology, held on June 10, the degree of Doctor of Engineering was conferred upon Alexander G. Christie, President of the American Society of Mechanical Engineers and Professor of Mechanical Engineering at The Johns Hopkins University, in recognition of his contributions to the advancement of engineering with special reference to the power field.

Doctor Christie is a graduate of the University of Toronto and early became associated with steam turbines at the works of the Westinghouse Machine Company and the Allis-Chalmers Company. His teaching career began at Cornell University in 1904, followed by five years at the University of Wisconsin from which he was called to his present position.

Aside from educational work, Doctor Christie has given much time to consulting practice in the steam turbine and general power plant field and has served as advisory engineer on a number of outstanding steam power projects both in this country and abroad.

Field Organizations Combine Efforts

The Buell Engineering Company, of New York, and the B. F. Sturtevant Company, of Hyde Park, Boston, have completed arrangements whereby the Sturtevant field organization, operating out of the forty Sturtevant offices, will parallel the work of the Buell service staff, thus greatly increasing service facilities on Buell dust and fly-ash collectors throughout the country.

The present field organization of the Buell Engineering Company, retained intact, will continue to function as in the past. The Buell testing laboratory, in New York, will be complemented by the Sturtevant laboratory in Boston, and the Van Tongeren laboratory in Holland, which devotes itself to the scientific solution of dust problems, will cooperate closely with both of the American laboratories.

A.S.M.E. Semi-Annual Meeting at San Francisco

The Semi-Annual Meeting of the American Society of Mechanical Engineers will be held in San Francisco, July 10 to 15. There will be fourteen technical sessions, sponsored by the Aeronautic, Fuels, Hydraulic, Heat Transfer, Power, Management, Process Industries, Oil and Gas Power, and Materials Handling Divisions of the Society. Among the 28 papers scheduled the following hold interest for power engineers:

"Some Problems in the Burning of Fuel Oil" by A. W. Anderson
"Design and Operation of De Florez Furnaces" by George C. Leslie
"Characteristics of Atmospheric Type Burners When Used with Natural Gas" by E. D. Howe and H. G. Johnson
"Boiler Performance with Natural-Gas Firing" by F. G. Philo
"Elements Entering into the Exact Measurement of Natural Gas" by John Overbeck and S. R. Beitler
"An Improved System in the Application of Non-Condensing or Extraction Turbines" by H. W. Cross and E. S. Wells, Jr.
"Gas Turbine Problems" by Adolphe Meyer
"Performance Characteristics of a Mechanically Induced-Draft, Contraflow, Packed, Cooling Tower" by A. L. London, W. E. Mason and L. M. K. Boelter
"Fundamental Relationships in the Design of Cooling Towers" by G. R. Nance
"The Flow of Water in Channels under Steep Gradients" by W. F. Durand
"The Economic Thickness of Insulation for Pipes in Intermittent Service" by R. L. Perry and W. P. Berggren
"Problems in the Design and Operation of Impulse Turbines" by R. S. Quick
"Pump Discharge Valves on the Colorado River Aqueduct" by R. M. Peabody

The Calvin W. Rice Lecture will be delivered by Dr. R. E. Ballester of Argentina.

The Golden Gate International Exposition has designated Thursday, July 13, as Engineers Day in which the A.S.M.E. will participate. A feature of this will be an address by Herbert Hoover, who will discuss the contributions which engineering has made to human welfare.

A varied program of plant visits, trips to points of interest and social functions has been arranged.

Official headquarters for the meeting will be at the Fairmont Hotel, where the majority of the technical sessions and social affairs will take place.

A. S. T. M. Annual Meeting

Twenty-two technical sessions and 110 papers are scheduled for the Forty-Second Annual Meeting of the American Society for Testing Materials, to be held at the Chalfonte-Haddon Hall, Atlantic City, N. J., June 26 to 30, inclusive. Many topics in the fields of standardization, research, water treatment, fatigue of metals and the testing of engineering materials will be covered, and a round-table discussion will be devoted to the effect of sub-atmospheric temperatures on the properties of metals. The presidential address by T. G. Delbridge will be entitled "Glimpses at Petroleum" and the Edgar Marburg lecture, scheduled for Wednesday at 4 p.m., will be delivered by Prof. H. F. Moore who will discuss "Stress, Strain and Structural Damage." Throughout the week the exhibit of testing apparatus and related equipment will be in progress; also, a photographic exhibit and competition on the theme of "Testing and Research in Engineering Materials," which will comprise photographs of apparatus, instruments and testing procedures.

Electric Power Statistics

These statistics covering electric energy for public use, as compiled by the Federal Power Commission, deal with installed capacity, output, plant factors and fuel consumption arranged as to type of plant and character of ownership. Fuel-burning plants account for 71.7 per cent of the installed capacity and 61.6 per cent of the electric output. Privately owned plants produced 91 per cent of the total output of both fuel-burning and hydro plants.

THE Federal Power Commission has just issued a comprehensive report on electric power statistics for 1938. This covers all power generated for public use in the United States but does not include those plants that generate power for their own use, such as manufacturing establishments, hotels, office buildings, etc. In all, 4088 plants are reported, of which 2788 are owned by 564 private electric utilities, 1115 are publicly owned and 185 represent mining, manufacturing and railway plants supplying power for public use.

The statistics are grouped as to class of ownership (public or private), installed capacities, type of fuel and hydroelectric, output, plant factor (the ratio of the average load on the plant for the given period to the installed capacity), and the fuel per kilowatt-hour. Comparative figures from 1920 through 1938 are included and much of the data are broken down into regional and state figures.

Installed Capacity

The installed capacity in service as of December 31, 1938 was 39,042,105 kw which represented an increase of 1,907,723 kw during the year. Of this total 27,202,844 kw was in steam stations, 11,066,063 kw in hydroelectric plants and 773,198 kw in internal-combustion engines. Hydro represented 28.3 per cent of the total.

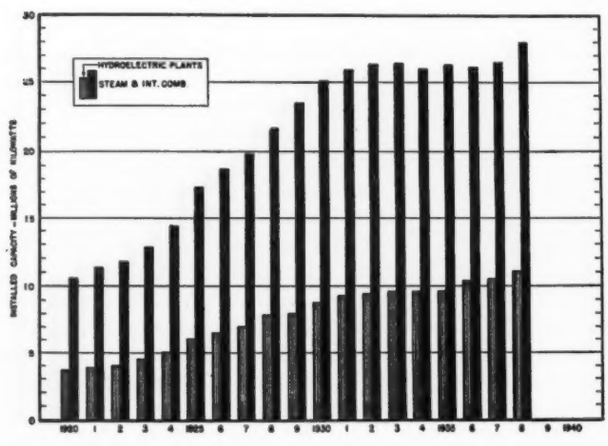


Fig. 1—Installed capacity of electric generating plants, according to type, 1920 to 1938

Private ownership accounted for 89 per cent of the total installed capacity, over 92 per cent of the fuel burning capacity and 81 per cent of the hydro. In other words, the privately owned stations represented 25,803,249 kw in fuel-burning plants and 8,993,102 kw in hydro as compared with public ownership of 2,172,793 kw in fuel burning capacity and 2,072,961 kw of hydro.

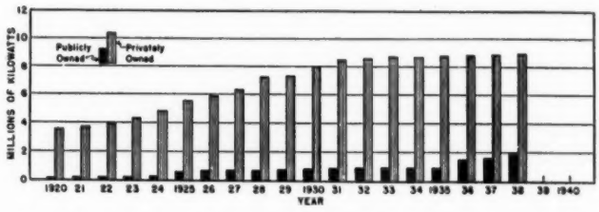


Fig. 2—Installed capacity of hydroelectric plants, according to ownership, 1920 to 1938

However, of the 1,907,723 kw added during the year, 1,418,274 kw was in steam capacity and 489,449 kw in hydro capacity; of the latter 416,713 kw represented public ownership and only 72,736 kw private ownership. From this it will be seen that while Federal power development accounted for most of the new hydro capacity added, this was only about a third of the steam capacity added by private utilities.

TABLE 1—ANNUAL CONSUMPTION OF FUEL FOR PRODUCTION OF ELECTRIC ENERGY

1920 to 1938, Inclusive

	Coal		Fuel Oil		Gas		
Year	Short Tons (2000 Pounds)	Change from Previous Year, Per Cent	Barrels	Change from Previous Years, Per Cent	Thousands of Cubic Feet	Change from Previous Year, Per Cent	Pounds per Kilowatt-hour
1920	42,938,000	....	10,466,000	....	21,861,000	....	3.39
1921	31,575,000	−26.5	12,046,000	+15.1	23,716,000	+ 8.5	2.70
1922	34,171,000	+ 8.2	13,224,000	+ 9.8	27,181,000	+14.6	2.50
1923	38,966,000	+14.0	14,681,000	+11.0	31,486,000	+15.8	2.40
1924	37,563,000	− 3.6	16,643,000	+13.4	48,465,000	+53.9	2.20
1925	40,217,000	+ 7.1	10,264,000	−38.3	46,526,000	− 4.0	2.10
1926	41,329,000	+ 2.8	9,430,000	− 8.1	53,694,000	+15.4	1.95
1927	41,887,000	+ 1.4	6,784,000	−28.1	62,922,000	+17.2	1.84
1928	41,390,000	− 1.2	7,154,000	+ 5.5	77,426,000	+23.1	1.76
1929	44,934,000	+ 8.6	10,185,000	+42.4	112,621,000	+45.5	1.69
1930	42,910,000	− 4.5	9,263,000	− 9.1	120,297,000	+ 6.8	1.62
1931	38,714,000	− 9.8	8,129,000	−12.2	139,274,000	+15.8	1.55
1932	30,296,000	−21.7	7,967,000	− 2.0	107,840,000	−22.6	1.50
1933	30,575,000	+ 0.9	9,953,000	+24.9	102,726,000	− 4.7	1.47
1934	33,561,000	+ 9.8	10,391,000	+ 4.4	127,892,000	+24.5	1.47
1935	34,164,000	+ 1.8	11,378,000	+ 9.5	125,239,000	− 2.1	1.46
1936	42,025,000	+23.0	14,119,000	+24.1	156,080,000	+24.6	1.44
1937	44,766,000	+ 6.5	14,143,000	+ 0.2	171,268,000	+ 9.7	1.43
1938	40,212,000	−10.2	13,077,000	− 7.5	170,688,000	− 0.3	1.41

The chart, Fig. 1, shows graphically the installed capacity of electric generating plants, grouped as to hydro or fuel burning, from 1920 through 1938. From this it will be seen that the rate of increase was nearly

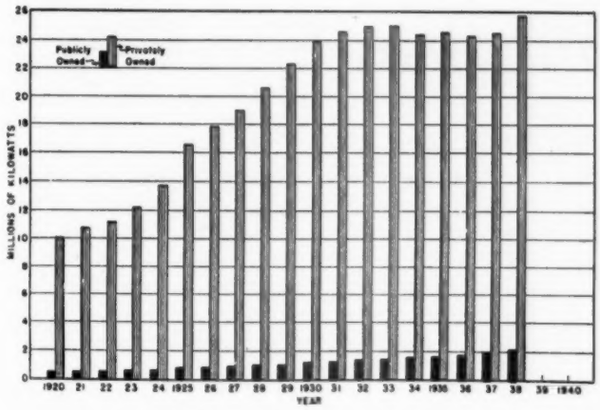


Fig. 3—Installed capacity of fuel-burning plants, according to ownership, 1920 to 1938

constant from 1920 to 1931, following which the capacity remained almost stationary for six years, with some slight decreases representing retirement of equipment, and a noticeable increase in 1938. Figs. 2 and 3 which show the installed capacity of hydro and of fuel-burning plants at the end of each year, according to ownership, indicates clearly the relative positions of private and publicly owned plants.

Output of Electricity

The total production of electricity for 1938 was 116,681,423,000 kwhr, of which hydro accounted for 38.4 per cent and fuel-burning plants 61.6 per cent. Of this total, privately owned plants produced 91 per cent.

Table 1 gives the annual consumption of fuel in the fuel-burning plants for the past 18 years from which it will be noted that the total coal consumption is now about what it was in 1920 despite 2.7 times the output.

TABLE 2—PLANT FACTOR BY TYPE OF PRIME MOVER AND BY CLASS OF OWNERSHIP

1920 to 1938, Inclusive

Year	All Plants, Per Cent	Hydroelectric Plants, Per Cent	Fuel Plants, Per Cent	Privately Owned Plants, Per Cent	Publicly Owned Plants, Per Cent
1920	34.3	48.0	29.5	34.7	27.8
1921	31.5	43.8	27.1	31.7	27.9
1922	34.7	47.8	30.1	35.0	30.1
1923	38.0	49.9	33.7	38.4	30.6
1924	36.3	46.4	32.7	36.6	29.7
1925	34.9	44.9	31.3	35.4	26.7
1926	34.4	46.5	30.1	34.7	29.5
1927	34.6	48.1	29.7	34.8	31.8
1928	34.7	50.0	29.1	35.0	30.1
1929	35.7	46.7	31.8	36.2	28.8
1930	32.9	42.4	29.6	33.2	28.6
1931	29.8	36.7	27.4	30.1	25.2
1932	26.3	39.9	21.3	26.4	24.5
1933	26.8	40.3	21.9	27.0	24.2
1934	28.8	39.5	24.8	29.2	23.7
1935	31.3	45.6	25.9	31.7	26.2
1936	35.2	44.5	31.6	35.9	27.1
1937	37.7	48.3	33.5	38.8	27.7
1938	35.0	47.3	30.1	35.8	28.1

While this has been due in part to a large increase in natural gas consumption and some increase in oil, it is due mainly to the steadily decreasing fuel consumption per kilowatt-hour as shown in the last column of the table, which, expressed in coal equivalent, is now 1.41 lb per kwhr sent out from the plants.

Plant factors, by type of prime mover and by class of ownership, computed by dividing the actual output for the year by the aggregate rating of the average installed capacity for the year, multiplied by the hours during that year, are given in Table 2. While this factor for all types of plants ranged from a low of 26.3 during 1932, the worst year of the depression, to 37.7 during 1937, it will be noted that the figures for the hydro plants are consistently higher than those for the fuel-burning plants and the privately owned plants higher than those publicly owned.

During 1938, 1,885,316,000 kwhr was imported from Canada and 110,000 kwhr from Mexico. The amounts exported to these countries were 3,656,000 kwhr and 15,021,000 kwhr, respectively. This represented largely energy produced by water power.

Charts are also incorporated in the report showing the quantities of electricity crossing various state lines. In such interchange of energy every state except Maine was involved.

Conveying Oil-Treated Coal

Oil treatment of coal to reduce dust and also reduce the rate of oxidation of coal in storage is now being employed in many power plants. It has, however, introduced a problem where the coal is subsequently handled by rubber conveyor belts.

At the plant of the Stamford Gas & Electric Company a rubber-covered belt conveyor of 100 tons per hour was employed to carry $^5/_8$-in. slack 230 ft up a 12-deg rise. Although it had previously given entire satisfaction, when a switch to oil-treated coal was made, the belt began to soften so that it stretched, slipped and wouldn't track, and the tension had to be changed frequently. Moreover, the oil-softened rubber was easily abraded by the coal. After five months the cover swelled to such an extent that the belt humped and dumped the coal off the sides. The quantity of oil used was about seven quarts per ton of coal.

To overcome this difficulty the company secured a neoprene covered conveyor belt and installed it in place of the rubber covered belt. This belt has now been in service for more than a year without any signs of softening or slipping and it has successfully withstood abrasion from the coal. A close-up view of the belt, taken where it passes under the loading hopper, is shown in the accompanying illustration.

Neoprene belt passing under loading hopper

Chicago's Air Pollution Survey

The W.P.A. has recently embarked upon a comprehensive air pollution survey of Chicago and vicinity, $392,000 having been appropriated for the study. This project is sponsored by the Armour Institute of Technology, Lewis Institute and the City of Chicago, and is set-up to operate until December 1939.

The survey is essentially a fact-finding investigation and consists of six interrelated studies of various phases of air pollution. The groups to be investigated are:

1. Visible smoke.
2. Dust and noxious gases in the air.
3. Origin of dust and noxious gases.
4. Ultra-violet and visible light penetration through the atmosphere.
5. Abstracting scientific literature.
6. Collection and codification of legal opinions and decisions affecting air pollution.

Division A is a study of smoke produced in all sections of the city by various classes of plants, employing many types of fuel burning equipment. The data obtained will be used to compare the relative amount of smoke made by various classes of plants; to compare present smoke conditions with those existing during periods when previous surveys were made; to compare relative air pollution in different sections of the city; and to correlate smoke produced with various types of equipment and fuel. To this division approximately two hundred and fifty men have been assigned.

When this part of the survey has been completed it should be possible to determine:

1. The relative ability of various types of stokers to operate smokelessly.
2. What difference exists between the various types of boilers in their ability to operate smokelessly.
3. What difference in smoke emission exists between hand firing and mechanical firing.
4. Variations in smoke made by different fuels.
5. Variation in amount of smoke made by different fuels burned on different types of equipment.
6. Principal causes of smoke for various types of equipment.

Division B of the present study is an investigation of the contaminating constituents of the air. Analyses of concentration and particle size range of solids suspended in the air are being made. Determinations are being run of the amount, composition and nature of the dust settling upon the ground within the city limits. An attempt is also being made to determine what percentage of this total amount originates from non-fuel-burning activities. Deposited dust is being examined under the microscope and with the aid of the spectroscope in an effort to find a method for identifying its source.

The concentration of sulphur compounds in the atmosphere will be determined in selected representative locations under varying weather and wind conditions.

Closely linked to the survey of atmospheric pollutants is the investigation to be made under Division C which deals with a study of the sources of such contamination. The problem of excessive fly-ash discharge by forced-draft firing equipment is coming to be of great concern to smoke abatement officials and to manufacturers of firing equipment who are required to conform to the regulations of these officials and there exists a very urgent demand for a simple method for making such determinations. The ideal test procedure should be readily adaptable to numerous stacks, take a short time to run and require the use of analysts of but slight technical training. No such method exists today. All of the present methods require elaborate equipment and highly skilled operators. Moreover, no procedure has been accepted as standard. Therefore, several of the most promising methods are being tried in an effort to find the most suitable procedure These fly-ash determinations will be made upon the many combinations of boilers, firing equipment and fuels in use in the Chicago area so that conclusions can be drawn concerning rate of burning, furnace volume, turbulence, heat release, length of flame travel, initial and sustained temperature during flame propagation, re-radiating surfaces, water-cooled surfaces, fuel feeding equipment, size and kind of coal, zoning of air blasts, baffling of boiler and size and location of ash settling or collecting chambers.

In addition to the determination of fly-ash loadings from typical boiler plants Division C will attempt to make the following studies of sulphur compounds:

1. Variation in concentration of SO_2 in flue gas under different load conditions in the same plant, burning a given fuel.
2. Variation in concentration of SO_2 under same load conditions, but with different types of equipment burning a given fuel.
3. Variations in SO_2 concentrations in flue gas from constant load and equipment with various fuels.
4. Percentage of sulphur retained in waste removed from the grate.
5. Cause of visibility of discharge from chimneys burning high sulphur coals. A few years ago engineers of the Chicago Smoke Department showed that stacks serving plants burning high sulphur coals always discharge a visible emission which varies from a light white haze to an almost opaque white cloud. This observation led to the theory that such visible emission was due to the condensation of sulphuric acid in the flue gas. An attempt will be made to establish the validity of this theory.

Division D is devoted to an investigation of the ultra-violet and visible light energy reaching the inhabitants of Chicago during the four seasons. The causes of the depletion of anti-rachitic and erythemal doses of the sun's rays will be studied. The loss of ultra-violet energy will be correlated with the amount of smoke, dust and noxious gas in the atmosphere.

Twenty-five stations spread over the entire city will be used to secure measurement of ultra-violet and visible light energy reaching every section of the city.

The purpose of Division E of this project is to review the existing literature on air pollution and make such information easily available to the engineer.

Division F will attempt to codify legal opinions interpretations, rules, regulations and standards dealing with air pollution both in the United States and abroad.

Cleaning Boiler Heating Surfaces*

By F. W. LINAKER
Vice-Pres., The Bayer Company

After briefly reviewing the history of soot-blower development, the author discusses the present gun-type retractable form of blowers with particular reference to their proper location in modern steam generating units. He also offers suggestions to operators for avoiding tube cutting, through direct and prolonged impingement of the steam, and nozzle wear by the sandblast action of grit.

THE development of methods for cleaning heating surfaces of boilers has necessarily followed the developments of the boiler itself, together with that of the superheater, economizer and air preheater. About forty years ago the commercial development of soot blowers began. Boilers in those days were small and of simple design. Various types of horizontal water-tube boilers predominated in the water-tube boiler field, although the bent-tube boiler was on the way. Hand-fired furnaces were common and stokers were being developed, but the power plant was operated at very low ratings, and to meet these operating conditions, the soot blower, in a simple form, was just coming into use. In fact, the soot blower was a very crude piece of equipment, consisting of a collection of stationary nozzles to clean the high temperature zones and a series of perforated stationary pipes extending across the boiler to clean the lower temperature zones. In those days, to clean a 500-hp boiler, it was common to have as many as forty openings in the boiler setting, through which the stationary nozzles and pipes of the soot blower would be installed.

About 1911 the revolving soot blower came into use. The number of openings in the boiler setting was cut down from around forty to five or six. At that time there were no heat-resisting alloys available and soot blowers were made from common pipe and at first located away from the high-temperature zones. The high-temperature zone at the entrance to the first pass was still cleaned by stationary nozzles set in the side wall. Later, protected soot blower elements were developed, shielded in some cases by baffles or tile and used in the high-temperature zone in the first bank of bent-tube boilers or below the front header in horizontal water-tube boilers. Soot blowers were made from the only materials available, steel pipe or cast iron with screwed nozzles and naturally oxidization took place; nozzles wore out of shape, or worse, blew out entirely and steam impingement damaged parts of the boiler.

As time went on, the boiler manufacturers in collaboration with the stoker and pulverized coal equipment manufacturers, boosted boiler capacities and this necessitated more thorough cleaning of heating surfaces. Soot blowers had to be placed right in the path of high-temperature gases. Heat-treated soot blower elements and elements sheathed with heat-resisting material were developed.

Slag trouble became more common, creating another problem for the soot-blower manufacturers. The prevention or removal of slag formation was tackled in various ways, the object of the soot-blower manufacturer being to develop mechanical means to replace the tedious manual methods then being used, both in this country and abroad. Toward the end of the World War some very poor grades of coal were being fired in Europe, particularly in Germany, and over there the practice in many plants was to use a water lance. An energetic man with a long enough lance could do a pretty good job by directing the water jet at close range. He could also do a good job with a steam lance, but that was hot and harder to handle and for awhile the use of water was looked upon with favor. Some plants in this country followed the practice.

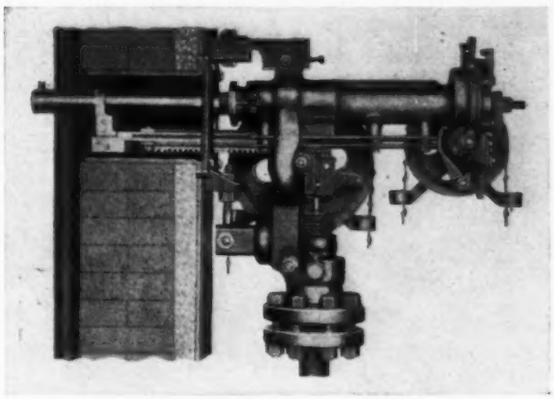


Fig. 1—Gun-type retracting soot blower installed for water-wall service

One soot-blower manufacturer developed slag removal steam jet cleaners in the form of stationary elements located close to the slagging zones. Later on, another manufacturer developed a water-cooled water jet element. Such equipment helped, but in many cases maintenance was high. Removal of slag deposits pre-

* From a paper before the National Board of Boiler and Pressure Vessel Inspectors, New York, May 17, 1939.

sented a real problem, because the most important thing to keep in mind when considering the cleaning of boiler heating surfaces is the vital necessity of keeping open the gas passages at the entrance of the first pass, throughout the first bank of tubes and the superheater. If these passages become excessively fouled or plugged, boiler capacity drops, superheat cannot be regulated and furnace temperature may become too high.

The gun-type retracting cleaner has proved particularly adaptable for the cleaning of slag from water-wall furnace tubes and the high-temperature zones of the boiler itself. Fig. 1 illustrates such a cleaner as installed for water-wall service. The nozzle is shown in the advanced or cleaning position. Normally, the nozzle is retracted behind the tubes within the recess casting set in the wall. The nozzle is advanced or projected into the furnace by means of a rack and pinion. After it has passed the water-wall tubes and just before it reaches the cleaning position the steam valve is automatically opened. The cleaner is then rotated over the cleaning arc by a worm wheel drive. When the cleaning has been done, the nozzle is again retracted. The valve automatically closes to shut off the steam and only after the valve has closed is the nozzle retracted within the recess casting. Closing the steam valve before the nozzle is retracted insures against damage to water-wall tubes as the nozzle is withdrawn.

By changing the design of the nozzle, such cleaners are readily adapted to cleaning the high-temperature zones of the boiler itself, slag screens or first-pass tubes. An installation for horizontal water-tube boilers is shown in Fig. 2. In this case the cleaners are installed below the front header and there may be one, two, three or more such cleaners, depending upon the width of the furnace and the steam pressure.

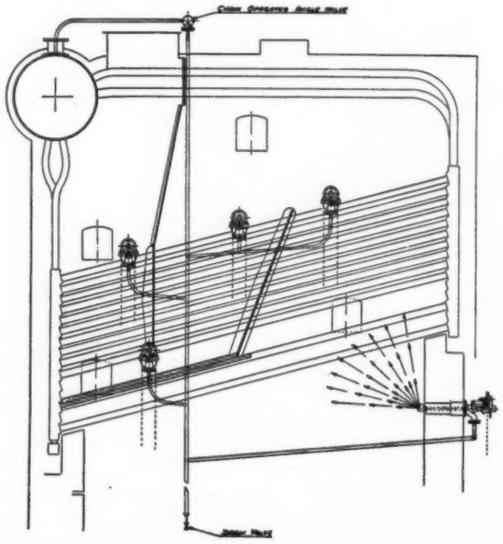


Fig. 2—Showing location of soot blowers in horizontal water-tube boiler

The practical utility of these cleaners was recently demonstrated in a plant where bent-tube boilers are installed. While built for high pressure the plant is at present operating at 160 lb with chain-grate stokers burning Illinois coal. Originally, transverse rotary soot blowers were installed to clean the first pass, but due to the low pressure and the slag formation which built up on the front tubes, the boiler had to be shut down periodically to clean off the slag by hand. An intertube superheater was later installed in the first pass and the transverse rotary soot blower was then re-located behind the superheater. As was to be expected, shutdowns for deslagging were more frequent. After a shutdown, and

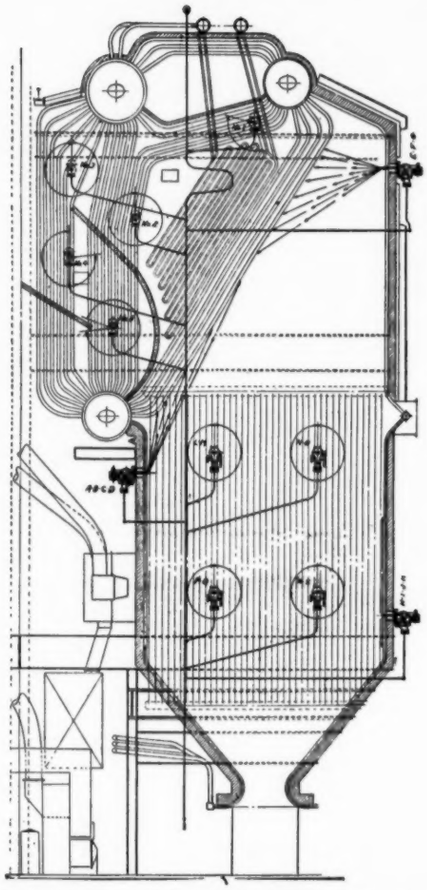


Fig. 3—Illustrating successful application of gun-type cleaners in high-temperature zone of large bent-tube boiler

the boiler went on the line clean, gas temperature leaving the boiler to enter the air preheater gradually rose to 640 F. Then gun-type cleaners were installed to clean the upper part of the first pass and superheater. Slag formation was prevented and between blowings exit gas temperature never went above 585 F. Whenever these gun-type cleaners were blown, the exit gas temperature was brought down to 570 F, which was approximately the same as when the boiler went on the line clean. This is a very worthwhile saving in itself besides having eliminated shutdowns for deslagging.

It is, of course, in the high-temperature zones that soot blowers have given most trouble. In some cases, elements have warped, burned and otherwise been a source of grief to the operator and high maintenance expense to management. It is no use denying this condition exists in some plants today; but the soot-blower manufacturer is not entirely responsible for this because if, in the past, purchasers had been willing to spend a little more money to buy equipment especially designed to suit their conditions of service, this kind of trouble could have been reduced materially.

Fig. 3 is a striking illustration of what has just been said. These bent-tube boilers generate 320,000 lb of

steam per hour and operate at 675 lb pressure. There has not been a single soot-blower element failure. It will be noted that there are no transverse rotary blowers in the high-temperature zone, but instead, gun-type cleaners. The furnace width is 29 ft. Below the mud drum is a series of four gun-type cleaners, and at the top of the target water wall a series of three gun-type cleaners. The rest of the heating surface in the lower temperature zone is cleaned by conventional transverse rotary blowers.

Modern high-pressure, high-capacity boilers have created a need for more intensive study and special engineering on the part of the soot-blower manufacturer. Unfortunately, this apparently is not always fully realized by power-plant engineers or by the boiler manufacturers. This is unfortunate because without full cooperation from all concerned it is often impossible to install soot-blower equipment best suited to the conditions of service; whereas had there been consultation and cooperation in the early stages, minor changes in construction might have been made in order to provide for installation of soot-blower equipment best suited for that particular job. This can be done without materially affecting boiler design. All that is necessary may be the re-location of buckstays, or an access door, moving the joints of casing panels or the re-bending of a tube—all on paper—to allow installation of a soot blower in a preferred location. Later on, when fabrication has been started, these changes are sometimes difficult or seemingly impossible. This may appear irrelevant, but, nevertheless, it has in the past and still does sometimes seriously affect the installation, efficiency and service life of the soot blower.

Operating Suggestions to Avoid Tube Cutting

The matter of tube cutting by soot blowers deserves serious consideration, and it might be well to consider how this can happen. Tube cutting is generally due to direct impingement of the steam jets at short range, but this is not always so. Cutting has taken place at a distance of 18 in. with soot blowers using steam at 160 lb pressure. When signs of tube cutting are noticed, the men operating the soot blower should be questioned as to their methods of operation. It is well before questioning to have the operators use the blowers so that their methods may be observed. First, make sure they are not using wet steam. Second, see that they do not revolve the blower a little and then stop for an appreciable time. If they stop, the jets are playing on one spot and damage may result. The correct way to operate a soot blower is as follows:

First, make sure that the steam line is thoroughly drained. Crack the main steam supply valve and open the drain valve. Do not operate the blowers until the steam is dry. After once having started to operate a blower unit, the operator should slowly and continuously rotate the blower and should not stop for any length of time during the operation. After the last blower unit has been operated, the main steam supply valve should be closed and the drain valve opened.

Tubes also may be cut due to sandblast action. This is particularly true when the boilers are fired with pulverized coal and special care must be exercised to avoid this cutting. Soot blowers should not be located in pockets where fly ash or grit lodges. There is danger of fly ash being entrained by the steam jets, thus creating sandblast action. Sometimes it happens that fly ash or grit filters into the blower elements through the nozzles. If there is any quantity of this material in the blower element when the element is blown there will be a sandblast action on the nozzles themselves. In this case the nozzles will wear and steam jets get out of line and may cut the tubes. Nozzles so cut appear as though they had been filed with a three-cornered file. Steam jets from such worn nozzles are naturally deflected and may cut tubes. Sometimes the nearest tubes are not affected, but tubes even 12 to 18 in. away may be damaged. Where signs of impingement are noticed a very careful inspection should be made. The blower element should be examined to see that the nozzles are not worn and that they are correctly spaced between the tubes. If the nozzles are incorrectly spaced, this may be due to faulty installation, or it may be that movement between the boiler and the element has taken place.

It is not well to trust to a light alone to disclose damage to tube surface. If the bare hand is rubbed along the tubes near the soot blower, the sensitive sense of touch will detect abrasion when the eye has failed.

All manufacturers are striving to cooperate in order to furnish equipment which will give the best service to power plant operators. Nevertheless, due to unforeseen causes, conditions sometimes arise which do cause trouble. Whenever a boiler inspection is made and anything wrong with the soot blower is noticed, this should be reported to the engineer and the latter should communicate with the soot-blower manufacturer.

YOU DON'T PAY FOR WATER WHEN YOU BUY

Enco Baffle Material

Processed specially for Baffle Wall Construction and Repairs from the best refractories obtainable.

Packed dry in damp proof paper lined bags for convenient use. When mixed with water it sets without application of heat.

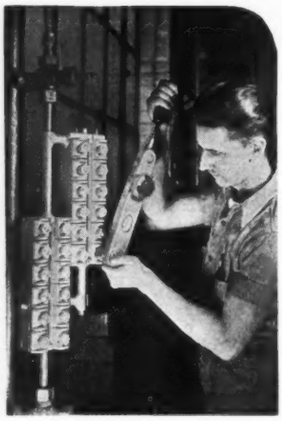
Used for 20 years in building and repairing Baffles in all types of WATER TUBE BOILERS.

Write for Bulletin BP-31

THE ENGINEER COMPANY
17 BATTERY PLACE NEW YORK, N. Y.

MODERN WATER LEVEL ALARMS AND INDICATORS FOR BOILERS

How RELIANCE uses modern methods to bring you *Safe, Dependable* Boiler Alarms and Water Level Indicators



Uniform predetermined tension on nuts clamping prismatic and flat glasses assured by indicating wrench calibrated in inch pounds.

Back of the time and money-saving efficiency of Reliance Products that help you regulate your boiler water levels is an unusual story of quality materials, precision and modern manufacturing methods. This photograph shows one example of the care that goes into every step of Reliance production. Whether your plant is large or small, high pressure or low, you can depend on one or more Reliance Devices to give you worry-free assurance of safe, accurate water level reading. Write today for full information.

THE RELIANCE GAUGE COLUMN COMPANY
5902 Carnegie Ave. • • • Cleveland, Ohio

BOILER SAFETY DEVICES SINCE 1884
★ **Reliance**

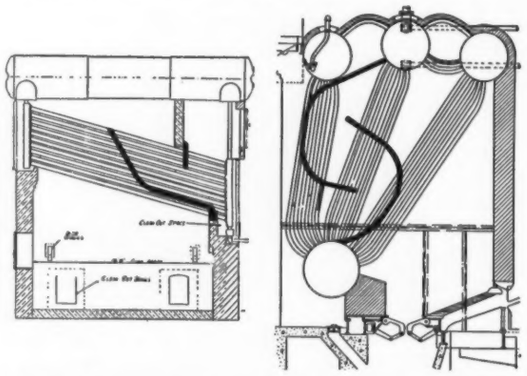
VULCAN SOOT BLOWERS

. . . are readily meeting high temperature conditions without makeshift in design, material or parts. The sound and proven principles of the Vulcan valve operating head, bearings and elements guarantee operating economies which make both the annoyance and cost of frequent servicing unnecessary.

VULCAN
SOOT BLOWER CORPORATION
DUBOIS, PENNSYLVANIA

Enco Baffle Walls

STREAMLINING BOILER BAFFLES —insure better heat distribution—eliminate eddy currents—permit soot blowers to work more effectively and keep the boiler clean for a longer period because there are no angle joints to form pockets that will collect soot and fly ash.



Bulletin B-37 describes in detail The Construction of Enco Baffle Walls and Their Application to Modern Boilers and the Modernization of Existing Plants.

Write for a copy.

THE ENGINEER COMPANY
17 BATTERY PLACE NEW YORK, N. Y.

KEEP YOUR STEAM GAUGE "Right on the Pin" WITH

IT'S THE BEST!

CHAMPION COAL

If you have an overload problem, you will find the ideal solution with Champion High B.T.U. Coal. It is scientifically processed, sized and prepared to deliver maximum evaporation, assures high burning rates and increased overall furnace efficiency. To try Champion is to be convinced of its extra value.

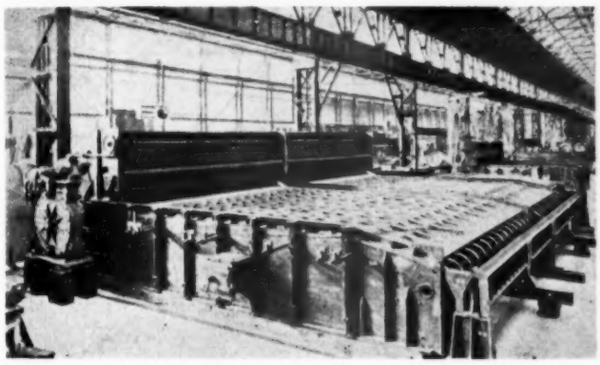
PITTSBURGH COAL COMPANY
Pittsburgh, Pa.
District Offices in Principal Cities

STEAM ENGINEERING ABROAD

As reported in the foreign technical press

Largest Traveling-Grate Stoker

Engineering and Boiler House Review for May describes a very large traveling-grate stoker that has just been completed at the Derby Works of International Combustion Ltd. for installation at the Hok-Un Station of the China Light & Power Company of Hong Kong. This stoker which will serve a 200,000-lb per hr, 400-lb pressure bent-tube boiler, is of the twin type measuring 36 ft 5 in. wide by 20 ft long and having a total grate area of 756 sq ft, for the two sections. It weighs



Twin stoker on shop erecting floor

160 tons, has 10,540 links and will burn 11 tons of coal per hour at the normal rate of about 30 ft per sq ft per hr. The grate travels at eight different speeds and is driven by a 5-hp motor. Preheated air will be supplied at 260 F and the fuel to be burned is semi-anthracite from Indo-China, Formosa, Japan or Hinan. These coals have an average heating value of around 12,000 Btu per pound gross, contain 11.8 per cent ash and about 8.7 per cent moisture.

This stoker is said to be the largest of its type built to date.

Performance at Dalmarnock

In a paper before the Institution of Mechanical Engineers (Great Britain) on March 23, W. E. Young gave some performance figures for the extension to Dalmarnock Station, Glasgow, which has now been in operation for more than a year. This extension (see COMBUSTION, November 1937) comprises two 50,000-kw turbine-generators and six 200,000-lb per hr Yarrow four-drum land-type boilers, fired with traveling-grate stokers and operating at 625 lb pressure, 850 F total steam temperature. Economizers are provided and the air leaves the air preheaters at around 225 F.

Each boiler can steam continuously at 230,000 lb per hr and outputs as low as 8000 lb per hr have been carried with stable conditions. The method of soot blower operation found to give most satisfactory results is to blow the furnace tubes one in each shift, the rear boiler banks and economizers every twenty-four hours and the air preheaters once a week. At first 1-in. nozzles were fitted in the front furnace soot blowers but these were found inadequate and were later enlarged to $1^5/_8$ in. after which it became possible to operate for periods of 2000 hr or longer without resorting to hand cleaning. About 200 lb of dust per hour per boiler is discharged from the dust collectors.

On test at a nominal evaporation of 180,000 lb per hr, 617 lb pressure and 846 F at the superheater outlet, with feedwater entering the economizer at 271 F and air leaving the air preheater at 225 F, an efficiency of 88.87 per cent was attained. The coal had a calorific value of 11,500 Btu per lb as fired. It contained 48.51 per cent fixed carbon and 30.61 per cent volatile, and the firing rate was 41.28 lb per sq ft of grate per hour. The heat balance was as follows:

Dry flue gas loss	3.48 per cent
Loss due to moisture and hydrogen	4.82 per cent
Loss due to combustible in ash and riddlings	0.30 per cent
Radiation and unaccounted for	2.53 per cent
Absorbed by steam generating unit	88.87 per cent

The day-to-day efficiency of the boiler plant is reported to be about 87 per cent. Compared with the old low-pressure, low-temperature section of the station the weekly coal saving, for the same output at the switchboard, is about 1500 tons, based on the operation of three boilers and one turbine-generator. The station efficiency for the six months of 1938, reported, was 27.3 per cent on the basis of power sent out.

37,500-Kw Radial-Flow Turbines

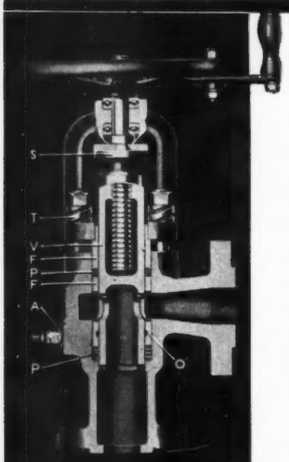
The latest extension to the Southwick Generating Station of the Brighton Corporation (England) includes two 37,500-kw Brush-Ljungström radial-flow turbine-generators, the first of which went into operation in January 1937 and the second in November 1938. These are described in the May 19, 1939 issue of *Engineering*.

Up to April 21, 1939 the first unit had produced 318 million kilowatt-hours in 13,000 running hours, carrying loads up to 42,000 kw and by that date the second unit had produced 73 million kilowatt-hours. On the official trials at a load of 30,000 kw and 650 lb pressure, 850 F total steam temperature and 29-in. vacuum, the steam consumption was 8.63 lb per kwhr, including the steam bled to raise the condensate to 334 F. This corresponds to a heat consumption of 9759 Btu per kwhr or a thermal efficiency of 35 per cent.

The turbine, a partial cross-section of which is here reproduced, consists of two disks which rotate in op-

YARWAY EQUIPPED . .

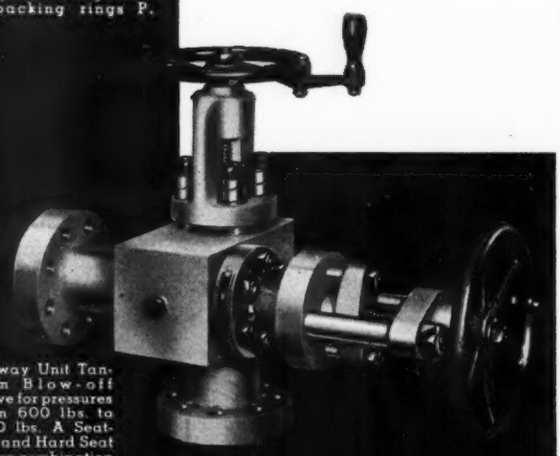
A Mark of Good Engineering



Yarway Seatless Blow-off Valve. Operation: After Valve is closed, shoulder S on plunger V contacts with upper follower gland F, forcing it down into body and compressing packing P above and below port. Annular groove O connects with Alemite fitting A for lubricating plunger and packing. Yoke springs T maintain continuous pressure through follower gland F on packing rings P.

Yarway Blow-off Valves are used singly or in tandem in more than 10,000 plants in 67 different industries . . . Regarded as a standard of quality by leading steam plant designers and builders of steam generating equipment . . . Selected for Federal, State and Municipal Institutions . . . Built for all pressures up to 2,000 lbs. . . . Write for Catalog B-417.

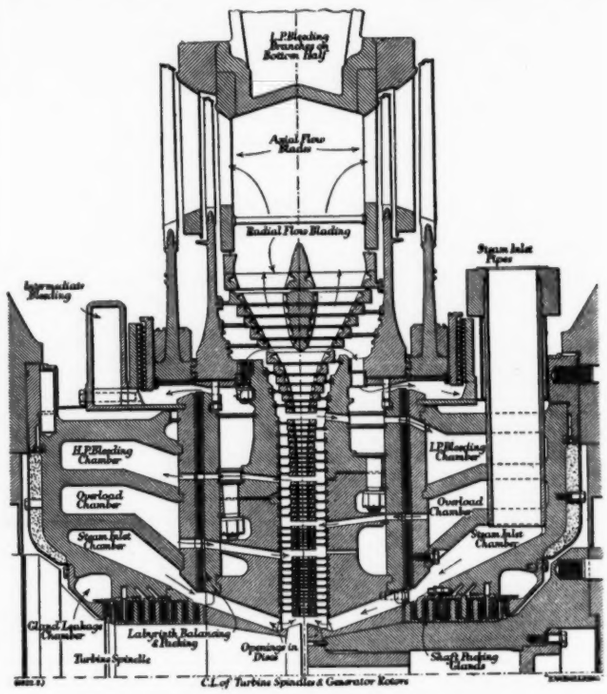
YARNALL-WARING COMPANY
101 Mermaid Avenue, Phila.



Yarway Unit Tandem Blow-off Valve for pressures from 600 lbs. to 1500 lbs. A Seatless and Hard Seat Valve combination using a common forged steel body.

YARWAY
BLOW-OFF VALVES

posite directions. These are mounted on short hollow shafts which overhang the inner bearings and are, in turn, spigoted and bolted to the ends of the main shafts which carry the generator rotors. The turbine rotors are fitted on the tapered ends of the hollow shafts and are secured in position by hollow locking bolts; driving keys also being employed. The rotors carry the blade rings flexibly mounted between them. Steam is admitted to the annular chamber in the two steam chests and thence to the inner blade ring, through ports which are arranged symmetrically around the turbine disks.



Cross-section through upper half of Brush-Ljungström turbine

Owing to the range of temperature between the inner and the outer part of the disk it is made in three parts, the outermost part carrying the first row of axial-flow blades.

There are 57 rings of radial-flow blading and two axial-flow single-rotation, low-pressure stages in each half of the turbine. The central position of the turbine in the casing enables the double-flow arrangement to be employed for the last stages, each turbine disk carrying these two rows of axial-flow blades in addition to its share of radial-flow blades.

At the most economical load of 30,000 kw the main steam supply passes from the inner compartments of each chest to the inside of the first ring through holes in the hubs of the disks. The next two connections, one for each chest, may be used for the admission of additional steam from the middle compartments to the lower pressure stages to permit maximum capacity to be carried. Two others are used for bleeding steam to the high-pressure heaters. Similarly, the low-pressure heaters are supplied with steam bled from two still lower pressure stages.

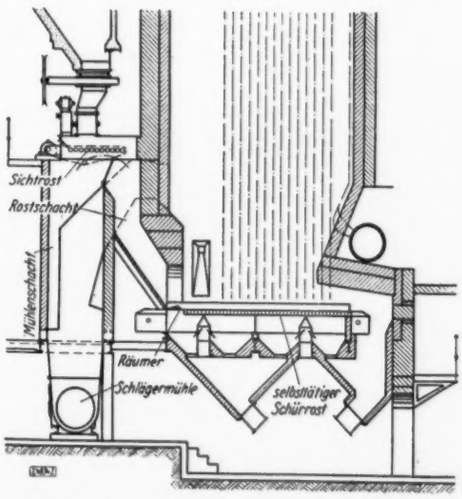
The radial flow blades, with their roots, are machined from the solid bar, and then built up into rings. Nickel-chrome-molybdenum strengthening rings, which carry the centrifugal load, are secured to the blade roots by

rolling over the dove-tailed roots of the blades. Thin packing strips which run safely within a fine clearance of the inner surface of the next ring minimize the possibility of steam leakage around the free end of the ring. In the high-pressure portion an arrangement of double packing strips is employed. Each half of the turbine rotates at 1500 rpm and the tip speed of the largest blade is 830 ft per sec. All the low-pressure blades are of stainless steel and provision is made for draining away the water of condensation from the exhaust stages.

Owing to the flexible construction of the blade system and the absence of long members exposed to a large temperature gradient, the turbine may be started without preliminary warming up. Advantage is taken of this property by installing a quick-start ejector which is capable of raising a vacuum of 24 in. in three minutes. In addition, there are two three-stage ejectors with intermediate surface condensers. One of these uses the main condensate as the condensing medium and the other, which is used only at low loads and when starting up, is supplied with sea water.

Combined Grate and Mill Firing

Zeitschrift des Vereines Deutscher Ingenieure of April 29, 1939 discusses an installation in which, when firing a certain coke with a Kraemer mill, the hammers lasted only 500 hr. Other coke caused less wear. While the wear was due partly to the mill loading and to the dryness of the coke, the size was the greatest factor. Extreme wear resulted when 25 to 40 per cent of the coke was over 10 mm, whereas much less was experienced when all pieces over 10 mm were screened out. By limiting the mill capacity to 3 tons per sq m (0.27 tons per sq ft) of grinding area per hour and keeping the sizing under 10 mm, wear was held to normal.



Combined grate and Kraemer mill firing
Sichtrost (separator); mühlenschacht (mill shaft); rostschact (hopper for grate); räumer (pusher); schlägermühle (hammer mill); selbsttätiger schürrost (automatic grate)

Where both coarse and fine coke are to be burned a combination of Kraemer mill and grate firing has been adopted as shown in the illustration. Here the coarse and fine coke are fed directly onto a small separator. The small pieces fall through the screen into the shaft to be ground by the mill, and some very fine particles are carried by the air stream directly to the furnace. The

McNeill Remote Boiler Water Eye Level Gage

NO WATER CARRY-OVER
NO BURNED BOILERS

A GAGE FOR ANY PRESSURE UP TO 2000 LBS

The McNeill Gage
Note the clear line of demarcation of the black indicating fluid by which the gage may be read at a wide angle range.

Outstanding Features

1. Water from the boiler or the connecting pipes to the gage never contacts the indicating glass so that it always remains clear and bright inside. It brings the *water-level down to eye-level* of the operator.

2. Being entirely hydrostatic in its action it cannot be less safe than the conventional water glass located at the top of the boiler. That it is operative may be checked at any time by the simple expedient of blowing down the water column to which it is connected.

3. *It is more accurate than the water glass connected at the water line on the boiler*, because it may be calibrated to be correct for the weight of the boiler water at its operating temperature. This high degree of accuracy is not possible with regular water column glass because of the inevitable difference in temperature between the water in the glass and that in the boiler.

4. The indicating glass does not erode or deteriorate with use; maintenance cost is therefore practically nil.

5. Safety of operation is greatly increased by having the knowledge of the water level unmistakably before the operator who controls the fire.

We also manufacture the Eclipse Smoke Indicator Systems of all types and arrangements—periscopes, photo-electric and both in combination. Write for bulletins on McNeill Products.

T. W. McNEILL ENGINEERING EQUIPMENT CO.
4057 W. VAN BUREN STREET, CHICAGO, ILL.

coarse coke remaining on the screen is delivered to the hopper feeding the grate which is of well-known Steinmuller type. The damper on the partition wall between the mill shaft and the hopper serves to grade the coal leaving the separator.

By this arrangement the grate may be used efficiently with the most suitably sized coke and the mill with the sizes that produce low power input and minimum wear.

Marine Forced-Circulation Boilers

The Shipbuilder and Marine Engine Builder (London) for April 1939 contains a paper on "Forced-Circulation Boilers and Their Application for Marine Purposes," delivered by Captain R. E. Trevithick before the North-east Coast Institution of Engineers and Shipbuilders. In support of this type of boiler the author points out that owing to the independent circulation it is possible to permit a much higher resistance to flow than with natural circulation, hence longer tubes of smaller diameter may be used and it is not necessary to give them a continuous upward trend. They can be placed in any positions that circumstances demand, either horizontally or vertically, and the direction of flow can, if necessary, be downward without fear of steam locks. This flexibility of arrangement is advantageous on shipboard.

Moreover, the designer can place the whole heating surface in one vertical duct, without baffles, and instead of it being necessary to give each tube a single pass from water drum to steam drum, the tubes can be bent into serpentine formation, each tube making ten or more passes across the gas path. In this way tube nests having 20 or more rows may be constructed and require the equivalent of only two rows of holes in the drums. The reduction in the number of holes, over that required for natural circulation, makes it possible to reduce the plate thickness for a given pressure and thus cut down weight.

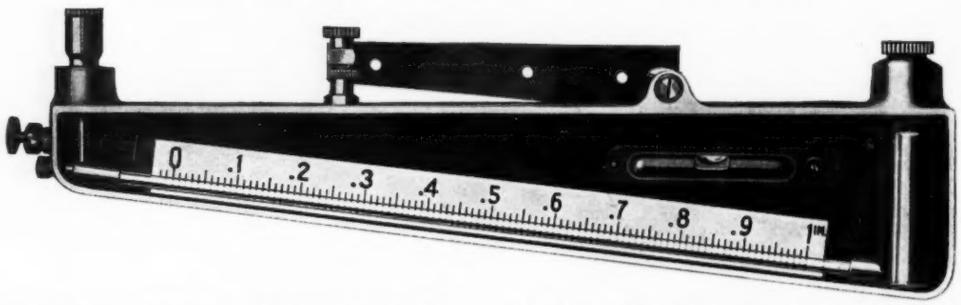
The author then describes the La Mont installation of two pulverized-coal-fired boilers on the steamship *Nicea*, built at Hamburg in 1933. Since then 17 ships, having 36 boilers of similar design, have been built or are under construction.

Analyzing a typical installation involving two boilers, each of 32,000 lb per hr capacity at 300 lb pressure and 650 F steam temperature, he shows a saving of 50 per cent in boiler room space and a reduction from 225 to 80 tons in weight over a comparable installation of Scotch marine boilers.

Turbine in Standby Service

An article by H. Quednau, appearing in the February 18 and 25 issues of *Die Wärme*, discusses various means of maintaining steam equipment in standby service ready for almost instantaneous operation. Among the various schemes described is the Stettin system as applied to turbine-generators. In this the standby machine is kept warm, under vacuum, and turning at low speed by steam extracted from a turbine that is carrying load, this steam first passing through the auxiliary turbine that drives the condenser circulating pump of the standby unit. The latter, it is claimed, can be brought up to full speed and ready to carry load in about a minute and the steam consumption during standby is said to be very small.

ELLISON INCLINED GAGE



Ellison Inclined Gages are manufactured by an engineering organization specializing in producing gages for draft and air flow measurements of outstanding design, construction and accuracy for laboratory, stationary and portable use.

This laboratory type gage is made in 10″ scale in 1, 1.5 and 2″ ranges and in 15″ scale in 2 and 3″ ranges in .01″ subdivisions, and in 5″ range, 15″ scale in .02″. It is in use in more than 200 research laboratories and engineering schools in the United States, and is accurate over the full range, error, if any, not to exceed .02 lineal inch, minus or plus, at any point on the scale. The scale is equipped with a screw adjustment for quickly and accurately setting the point of meniscus of the indicating liquid to zero.

The indicating tube is of straight and uniform bore and is provided with a cleanout for keeping the tube clean, essential for accuracy of readings. The suspension plate of the gage is also equipped with screw adjustment for setting zero. The nipples are brass bushed, bevel faced, against which lead gasket in the rubber tube adapters are seated.

The gages read minus, plus, or differential, and the indicating liquid used is petroleum oil, a special redistilled blend of fixed gravity, colored red; error, if any, not to exceed 1 in 1000.

"A Very Superior Inclined Gage"

ELLISON DRAFT GAGE COMPANY 214 West Kinzie Street Chicago

General Index of Articles and Editorials

(COMBUSTION—Vol. 10, No. 1, July, 1938, to and including Vol. 10, No. 12, June, 1939)

EDITORIALS—

		Page
Biennial Coal Problem, The	(May 1939)	23
Bituminous Coal Prices	(Mar. 1939)	23
British Technical Press Views Air-Raid Protection	(May 1939)	23
Capacity Margins	(July 1938)	17
Coal Mixtures vs. Ash-Softening Temperatures	(Sept. 1938)	25
Coal Selection	(Apr. 1939)	23
Comprehensive Survey, A	(June 1939)	23
Deductions from the Central-Station Statistics	(Jan. 1939)	15
Definition of pH, A	(Aug. 1938)	15
Designing for Reliability	(June 1939)	23
Enlightening the Public	(Aug. 1938)	15
Extensions to Power Capacity	(Nov. 1938)	23
High Pressures in the Marine Field	(Dec. 1938)	15
Hirshfeld, Dr. C. F.	(May 1939)	23
Intangible Factors Discount Evaluations	(Oct. 1938)	17
Lesson from Paris, A	(Oct. 1938)	17
Not So Important	(Aug. 1938)	15
Passamaquoddy Again	(Feb. 1939)	23
Performance vs. Normal Operation	(Aug. 1938)	15
Port Washington Still Leads in Performance	(Jan. 1939)	15
Power Allocations	(July 1938)	17
Power and National Defense	(Sept. 1938)	25
Professional Engineering versus Unionism	(Feb. 1939)	23
Research and Unemployment	(June 1939)	23
Savings through Welding	(Oct. 1938)	17
Slag Disposal	(July 1938)	17
SO_2 Pollution in Chicago	(Apr. 1939)	23
Standardized Steam Conditions and Capacities	(Dec. 1938)	15
Tube Failures	(Nov. 1938)	23
Years in College	(Mar. 1939)	23

ARTICLES—

		Page
Ash Disposal at the Schuylkill Station. By N. J. Walker	(Mar. 1939)	24
Axial Balance in Multi-stage Centrifugal Pumps. By A. Peterson	(Mar. 1939)	37
Bituminous Coal Industry Considers Research	(Feb. 1939)	43
Boiler Tests at Riverside Station	(Nov. 1938)	29
Burning Oil-Refinery Fuels. By A. L. Wilson	(Mar. 1939)	27
Calculation of Steam-Turbine Reheat Factors. By R. B. Smith	(Dec. 1938)	21
Central Station in One Man's Lifetime, The. By Geo. A. Orrok	(Sept. 1938)	34
Central-Station Statistics for 1938	(Jan. 1939)	20
Chicago's Air Pollution Survey	(June 1939)	36
Christie, A. G., New A.S.M.E. President	(Dec. 1938)	22
Chromates for Corrosion Prevention in Standby Boilers. By Richard C. Ulmer and J. Murray Decker	(Sept. 1938)	31
Cleaning Boiler Heating Surfaces. By F. W. Linaker	(June 1939)	37
Combination Oil and Pulverized Coal Burning. By Kingsley L. Martin	(Sept. 1938)	26
Considerations Affecting Selection of Pulverizers. By S. H. Reid	(Oct. 1938)	26
Conveying Oil-Treated Coal	(June 1939)	35
Corrosion in Partially Dry Steam Generating Tubes. By F. G. Straub and E. E. Nelson	(Apr. 1939)	38
Cracks in a High-Pressure Boiler Drum. By Prof. A. E. White	(Dec. 1938)	17
Cylinder Oil in Condensed Steam. By A. F. Brewer	(Feb. 1939)	41
Deaerators and Their Applications. By E. S. Daugherty and C. E. Joos	(Feb. 1939)	31
Design of High-Capacity Boilers. By John Van Brunt	(July 1938)	27
Determination of the Expansion Forces in Piping by Model Test, The. By H. W. Semar	(Dec. 1938)	18
Developments in Central Station Power Plants. By A. D. Bailey	(Apr. 1939)	40
Developments in High-Pressure, High-Temperature Valves. By V. T. Malcolm	(Nov. 1938)	24
Digest of Power Papers at A.S.M.E. Annual Meeting	(Dec. 1938)	16
Efficiency Comparisons of Turbine-Generators and Generating Stations. By James F. Field	(Feb. 1939)	37
Electric Power Statistics	(June 1939)	34
Evaporation Tests as a Measure of Coal Values. By G. B. Gould	(May 1939)	24
Fabricating Alloy Steels. By A. R. McLain	(Dec. 1938)	33
Factors Involved in Selection of Mechanical Draft Fans. By W. S. Patterson	(Aug. 1938)	21
Fouling and Corrosion of Air Heaters	(Apr. 1939)	28
Fuel Bed Tests at Hell Gate Station	(Dec. 1938)	22
Furnace Photography. By A. A. Markson	(June 1939)	24
Grindability of Some American Coals. By H. F. Yancey and M. R. Geer	(Sept. 1938)	37
Heat Rates of Some Recent Installations	(Feb. 1939)	30
High Pressure and Temperature in Marine Field. By L. M. Goldsmith	(Dec. 1938)	21
High-Pressure Steam Generators. By Henry Kreisinger	(Aug. 1938)	33
High-Temperature Steam Experience at Detroit. By R. M. Van Duzer, Jr. and A. McCutchan	(Dec. 1938)	20
Huge Press Installed to Bend Boiler Plate	(Sept. 1938)	47
Industrial Power. By C. W. E. Clarke	(Dec. 1938)	16
	(Jan. 1939)	21
Influence of Steam-Flow Metering Equipment on Piping. By R. M. Van Duzer, Jr.	(Dec. 1938)	19
Is America Ready for Forced-Circulation Boilers? By Alfred R. Smith	(Feb. 1939)	24
Judging Coal Values. By G. B. Gould	(Apr. 1939)	29
Laguna Verde Generating Station in Chile. By Louise Mann	(Apr. 1939)	24
Legal Relationship of Employers and Employees. By Leo T. Parker	(Sept. 1938)	39
Load Distribution on Turbine-Generators. By Y. C. Lu	(Jan. 1939)	28
Lubrication of Power Plant Auxiliaries. By A. F. Brewer	(Oct. 1938)	29
Method for Determination of Reactions and Stresses in Expansion Pipe Bends, A. By F. Peiter and Dr. M. J. Fish	(Dec. 1938)	26
Modern Boiler Furnaces. By E. G. Bailey	(Dec. 1938)	18
Modernized Brewery Power Plant. By William Schuler	(May 1939)	41
New Boiler Plant of Armour & Company	(May 1939)	32
New Power Plant Serving Industrial Rayon Corporation	(Dec. 1938)	24
New Topping Unit for L Street Station, Boston. By George A. Orrok, Jr.	(Nov. 1938)	35
New Unit Started at Ford Plant	(May 1939)	40
Operating Experiences with Large Turbine-Generators	(Sept. 1938)	30
pH and pOH Explained. By P. B. Place	(Mar. 1939)	33
Port Washington's Heat Rate	(Feb. 1939)	52
Port Washington's Third Year of Outstanding Performance	(Jan. 1939)	16
Power Plant Auxiliaries. By George C. Daniels	(May 1939)	29
Preferred Standards for Turbine-Generators	(Dec. 1938)	23
Purchase of Coal from Consumers' Viewpoint. By A. W. Thorson	(Nov. 1938)	33
Ramsin Once-Through Boiler, The. By T. Sauer	(July 1938)	35
Recent Practice in Power Piping. By Sabin Crocker	(Mar. 1939)	30
Recirculation of Boiler Salines, The. By S. M. Sperry	(June 1939)	27
Reheat Factors for Expansions of Superheated and Wet Steam. By Prof. C. G. Thatcher	(Dec. 1938)	21
Relation of Characteristics of Bituminous Coals to Their Use in Pulverized Firing. By E. R. Kaiser	(Nov. 1938)	41
Residual Stresses Due to Circumferential Welds in Pipes. By E. L. Eriksen and I. A. Wojtaszak	(Oct. 1938)	33
Selection of Economizers and Air Preheaters, The. By J. H. Sengstaken	(July 1938)	22
Single Boiler Meets Refinery Steam Requirements. By D. S. Frank and J. M. Augustus	(Apr. 1939)	35
Slag-Bottom Furnaces. By W. E. Caldwell	(July 1938)	18
Some Fundamentals of Feedwater Treatment	(Jan. 1939)	31
Stability of Colloidal Fuels. By C. H. S. Tupholme	(July 1938)	25
Steam and Feedwater Controls at Springdale	(Aug. 1938)	16
Steam and Power Costs Reduced at A. E. Staley Plant. By John C. Kuhns	(Oct. 1938)	18
Testing Boiler Waters for Embrittlement. By F. G. Straub and T. A. Bradbury	(Aug. 1938)	29
Treatment of Boiler Feedwater by Zeo-Karb Process. By Joseph D. Yoder	(May 1939)	35
Turbine Availability	(May 1939)	28
Unique Boiler Installation, A	(Sept. 1938)	33
Utilization of Pulverized Coal Ash. By A. W. Thorson and John S. Nelles	(Dec. 1938)	20

AUTHORS—

Augustus, J. M. and D. S. Frank—Single Boiler Meets Refinery Steam Requirements	(Apr. 1939)	35
Bailey, A. D.—Developments in Central Station Power Plants	(Apr. 1939)	40
Bailey, E. G.—Modern Boiler Furnaces	(Dec. 1938)	18
Bradbury, T. A. and F. G. Straub—Testing Boiler Waters for Embrittlement	(Aug. 1938)	29
Brewer, A. F.—Lubrication of Power Plant Auxiliaries	(Oct. 1938)	29
Cylinder Oil in Condensed Steam	(Feb. 1939)	41
Caldwell, W. E.—Slag-Bottom Furnaces	(July 1938)	18
Clarke, C. W. E.—Industrial Power	(Dec. 1938)	16
Industrial Power	(Jan. 1939)	21
Crocker, Sabin—Recent Practice in Power Piping	(Mar. 1939)	30
Daniels, George C.—Power Plant Auxiliaries	(May 1939)	29
Daugherty, E. S. and C. E. Joos—Deaerators and Their Applications	(Feb. 1939)	31
Decker, J. Murray and Richard C. Ulmer—Chromates for Corrosion Prevention in Standby Boilers	(Sept. 1938)	31
Eriksen, E. L. and I. A. Wojtaszak—Residual Stresses Due to Circumferential Welds in Pipes	(Oct. 1938)	33

PAGE

Field, James F.—Efficiency Comparisons of Turbine-Generators and Generating Stations....(Feb. 1939) 37
Fish, Dr. M. J. and F. Peiter—A Method for Determination of Reactions and Stresses in Expansion Pipe Bends....(Dec. 1938) 26
Frank, D. S. and J. M. Augustus—Single Boiler Meets Refinery Steam Requirements....(Apr. 1939) 35
Geer, M. R. and H. F. Yancey—Grindability of Some American Coals....(Sept. 1938) 37
Goldsmith, L. M.—High Pressure and Temperature in Marine Field....(Dec. 1938) 21
Gould, G. B.—Judging Coal Values....(Apr. 1939) 29
Evaporation Tests as a Measure of Coal Values....(May 1939) 24
Joos, C. E. and E. S. Daugherty—Deaerators and Their Applications....(Feb. 1939) 31
Kaiser, E. R.—Relation of Characteristics of Bituminous Coals to Their Use in Pulverized Firing....(Nov. 1938) 41
Kreisinger, Henry—High-Pressure Steam Generators..(Aug. 1938) 33
Kuhns, John C.—Steam and Power Costs Reduced at A. E. Staley Plant....(Oct. 1938) 18
Linaker, F. W.—Cleaning Boiler Heating Surfaces....(June 1939) 37
Lu, Y. C.—Load Distribution on Turbine-Generators..(Jan. 1939) 28
Malcolm, V. T.—Developments in High-Pressure, High-Temperature Valves....(Nov. 1938) 24
Mann, Louise—Laguna Verde Generating Station in Chile....(Apr. 1939) 24
Markson, A. A.—Furnace Photography....(June 1939) 24
Martin, Kingsley L.—Combination Oil and Pulverized Coal Burning....(Sept. 1938) 26
McCutchan, A. and R. M. Van Duzer, Jr.—High-Temperature Steam Experience at Detroit....(Dec. 1938) 20
McLain, A. R.—Fabricating Alloy Steels....(Dec. 1938) 33
Nelles, John S. and A. W. Thorson—Utilization of Pulverized Coal Ash....(Dec. 1938) 20
Nelson, E. E. and F. G. Straub—Corrosion in Partially Dry Steam Generating Tubes....(Apr. 1939) 38
Orrok, Geo. A.—The Central Station in One Man's Lifetime....(Sept. 1938) 34
Orrok, George A., Jr.—New Topping Unit for L Street Station, Boston....(Nov. 1938) 35
Parker, Leo T.—Legal Relationship of Employers and Employees. (Sept. 1938) 39
Patterson, W. S.—Factors Involved in Selection of Mechanical Draft Fans....(Aug. 1938) 21
Peiter, F. and Dr. M. J. Fish—A Method for Determination of Reactions and Stresses in Expansion Pipe Bends....(Dec. 1938) 26
Peterson, A.—Axial Balance in Multi-stage Centrifugal Pumps...(Mar. 1939) 37
Place, P. B.—pH and pOH Explained....(Mar. 1939) 33
Reid, S. H.—Considerations Affecting Selection of Pulverizers...(Oct. 1938) 26
Sauer, T.—The Ramsin Once-Through Boiler....(July 1938) 35
Schuler, William—Modernized Brewery Power Plant..(May 1939) 41
Semar, H. W.—Determination of the Expansion Forces in Piping by Model Test, The....(Dec. 1938) 18
Sengstaken, J. H.—Selection of Economizers and Air Preheaters, The....(July 1938) 22
Smith, Alfred R.—Is America Ready for Forced-Circulation Boilers? (Feb. 1939) 24
Smith, R. B.—Calculation of Steam-Turbine Reheat Factors....(Dec. 1938) 21
Sperry, S. M.—The Recirculation of Boiler Salines...(June 1939) 27
Straub, F. G. and T. A. Bradbury—Testing Boiler Waters for Embrittlement....(Aug. 1938) 29
Straub, F. G. and E. E. Nelson—Corrosion in Partially Dry Steam Generating Tubes....(Apr. 1939) 38
Thatcher, Prof. C. G.—Reheat Factors for Expansions of Superheated and Wet Steam....(Dec. 1938) 21
Thorson, A. W.—Purchase of Coal from Consumers' Viewpoint..(Nov. 1938) 33
Thorson, A. W. and John S. Nelles—Utilization of Pulverized Coal Ash....(Dec. 1938) 20
Tupholme, C. H. S.—Stability of Colloidal Fuels....(July 1938) 25
Ulmer, Richard C. and J. Murray Decker—Chromates for Corrosion Prevention in Standby Boilers....(Sept. 1938) 31
Van Brunt, John—Design of High-Capacity Boilers..(July 1938) 27
Van Duzer, R. M., Jr.—Influence of Steam-Flow Metering Equipment on Piping....(Dec. 1938) 19
Van Duzer, R. M., Jr. and A. McCutchan—High Temperature Steam Experience at Detroit....(Dec. 1938) 20
Walker, N. J.—Ash Disposal at the Schuylkill Station..(Mar. 1939) 24
White, Prof. A. E.—Cracks in a High-Pressure Boiler Drum....(Dec. 1938) 17
Wilson, A. L.—Burning Oil-Refinery Fuels....(Mar. 1939) 27
Wojtaszak, I. A. and E. L. Eriksen—Residual Stresses Due to Circumferential Welds in Pipes....(Oct. 1938) 33
Yancey, H. F. and M. R. Geer—Grindability of Some American Coals....(Sept. 1938) 37
Yoder, Joseph D.—Treatment of Boiler Feedwater by Zeo-Karb Process....(May 1939) 35

STEAM ENGINEERING ABROAD

British Industrial Installs LaMont Topping Unit....(Dec. 1938) 35
British Output of Electricity Shows Increase....(Jan. 1939) 36
British Power Supply....(Dec. 1938) 39
British Rules for Fusion-Welded Pressure Vessels....(Sept. 1938) 41
Clarence Dock Extension....(Jan. 1939) 35
Combined Grate and Mill Firing....(June 1939) 43
Comparison of Turbine Designs for Same Capacity...(May 1939) 44
Conserving Steel....(Mar. 1939) 44

PAGE

Corrosion in Fittings and Steam Lines....(Feb. 1939) 50
Corrosion of High-Pressure Feed Pumps....(Aug. 1938) 42
Creep and Recovery at High Temperatures....(Feb. 1939) 49
District Heating in Paris....(May 1939) 45
Electric Boilers in Switzerland....(Jan. 1939) 34
Gas Producers for Marine Use....(July 1938) 37
Grooved Boiler Tubes....(July 1938) 37
Guarding Boiler against Feed Interruptions....(Nov. 1938) 48
Heat Transmission in Combustion Chambers....(Dec. 1938) 35
Italy's Natural Steam Plants....(Feb. 1939) 47
Klip Generating Station....(Aug. 1938) 41
LaMont Boiler Tests....(Feb. 1939) 48
Large Mine Power Plant....(Jan. 1939) 35
Large Turbines in Japan....(Mar. 1939) 43
Largest Traveling-Grate Stoker....(June 1939) 41
Marine Forced-Circulation Boilers....(June 1939) 44
New Australian Power Station....(Mar. 1939) 44
New British Station Uses Both Stokers and Pulverizers....(Aug. 1938) 41
New Drumless Boiler, A....(Nov. 1938) 47
New Zealand Station Installs Velox Boilers....(Aug. 1938) 43
Novel Design of Chimney....(Apr. 1939) 43
Operating Experiences with LaMont Boilers....(Sept. 1938) 43
Operation at Hams Hall Station....(Apr. 1939) 43
Overfire Air....(Jan. 1939) 33
Per Capita Use of Electricity....(Sept. 1938) 42
Performance at Dalmarnock....(June 1939) 41
Power Plant of the "Mauretania"....(Sept. 1938) 41
Power Plant of the "Queen Elizabeth"....(Nov. 1938) 48
Pressure Drop in Pipe Lines....(Apr. 1939) 44
Pulverized Coal in Australia....(July 1938) 37
Radiation Boiler....(Oct. 1938) 35
Rebuilt Versus New Turbine....(July 1938) 37
Relative Heating Surfaces for Parallel and Counter Flow....(May 1939) 43
Savings Effected by the Grid System in England....(May 1939) 45
Scale Formation in Ramsin Boiler....(Oct. 1938) 35
Small Radial Turbine....(July 1938) 37
Some Large British Turbines....(Feb. 1939) 47
South African Plant Adds New Unit....(Jan. 1939) 36
Steam Transmission at Billingham....(Apr. 1939) 45
Steam vs. Diesels for Marine Service....(Feb. 1939) 51
Stuffing Boxes for Centrifugal Pumps....(Mar. 1939) 43
Sulphur and Dust Extraction at Fulham....(Jan. 1939) 33
Survey Shows Shortage of Engineers in Germany....(Oct. 1938) 36
Tangential Firing....(July 1938) 37
Test of Boiler at Barton Power Station....(Mar. 1939) 43
Testing Pipe Joints....(Apr. 1939) 46
Tests on a Schmidt High-Pressure Boiler....(Dec. 1938) 37
37,500-Kw Radial-Flow Turbines....(June 1939) 41
Trends in British Power Plant Practice....(Nov. 1938) 49
Tube Arrangement in Benson Boiler....(Sept. 1938) 41
Turbine in Standby Service....(June 1939) 44
Unusual Tube Failure, An....(Oct. 1938) 35
Velox Installation Completed in New Zealand....(Dec. 1938) 36
Water-Level Indicator for High Pressure....(Sept. 1938) 42
Wave Impulse Stoker....(May 1939) 43

REVIEW OF NEW BOOKS

Air Conditioning, Heating and Ventilating. By J. R. Dalzell and C. L. Hubbard....(Dec. 1938) 32
A.S.T.M. Specifications for Steel Piping and Piping Materials for High-Temperature and High-Pressure Services....(May 1939) 47
A.S.T.M. Standards on Coal and Coke....(Dec. 1938) 32
Combustion, Third Edition. Prepared by American Gas Association....(July 1938) 39
Combustion, Flames, and Explosion of Gases. By Bernard Lewis and Guenther von Elbe....(Dec. 1938) 32
Creep Data....(Mar. 1939) 41
Design of Industrial Exhaust Systems. By John L. Alden....(Mar. 1939) 41
Diesel Engines. By B. J. von Bongart....(Oct. 1938) 38
Diesel Engines, Theory and Design. By Howard E. Degler....(May 1939) 47
Elements of Steam and Gas Power Engineering. By A. A. Potter and J. P. Calderwood....(July 1938) 39
Engineers' Manual, The, Second Edition. By Ralph G. Hudson..(Mar. 1939) 41
Fatigue Test of Riveted Joints. By W. M. Wilson and F. P. Thomas....(Oct. 1938) 38
Heat Exchange Standards....(Dec. 1938) 32
How to Buy, Sell and Burn Coal. By Thomas A. Marsh....(May 1939) 47
Manual of Ordinances and Requirements....(Dec. 1938) 32
Mechanical Engineers Handbook—Design and Shop Practice. By Robert T. Kent, Editor-in-Chief....(July 1938) 39
Modern Furnace Technology. By H. Etherington...(Dec. 1938) 32
Practical Heat. By Terrell Croft, revised by R. B. Purdy....(May 1939) 47
Standards for Compressed Air Machinery....(Mar. 1939) 41
Steam and Gas Engineering. By T. E. Butterfield, B. H. Jennings and A. W. Luce....(Oct. 1938) 38
Steam-Engine Principles and Practice. By Terrell Croft, revised by E. J. Tangerman....(Mar. 1939) 41
Steels for the User. By R. T. Rolfe....(July 1938) 39
Superheater in Modern Power Plants, The. By D. W. Rudorff..(May 1939) 47
Test Code for Fans....(Oct. 1938) 38
Welding Handbook....(Oct. 1938) 38

CLASSIFIED INDEX—

Auxiliaries

PAGE

Axial Balance in Multi-stage Centrifugal Pumps. By A. Peterson. (Mar. 1939) 37
Developments in High-Pressure High-Temperature Valves. By V. T. Malcolm. (Nov. 1938) 24
Factors Involved in Selection of Mechanical Draft Fans. By W. S. Patterson. (Aug. 1938) 21
Lubrication of Power Plant Auxiliaries. By A. F. Brewer. (Oct. 1938) 29
Power Plant Auxiliaries. By George C. Daniels. (May 1939) 29
Steam and Feedwater Controls at Springdale. (Aug. 1938) 16

Boilers (Including Welding)

Boiler Tests at Riverside Station. (Nov. 1938) 29
Chromates for Corrosion Prevention in Standby Boilers. By Richard C. Ulmer and J. Murray Decker. (Sept. 1938) 31
Cleaning Boiler Heating Surfaces. By F. W. Linaker. (June 1939) 37
Cracks in a High-Pressure Boiler Drum. By Prof. A. E. White. (Dec. 1938) 17
Design of High-Capacity Boilers. By John Van Brunt. (July 1938) 27
High-Pressure Steam Generators. By Henry Kreisinger. (Aug. 1938) 33
Is America Ready for Forced-Circulation Boilers? By Alfred R. Smith. (Feb. 1939) 24
Ramsin Once-Through Boiler, The. By T. Sauer. (July 1938) 35
Single Boiler Meets Refinery Steam Requirements. By D. S. Frank and J. M. Augustus. (Apr. 1939) 35
Unique Boiler Installation, A. (Sept. 1938) 33

Coals

Bituminous Coal Industry Considers Research. (Feb. 1939) 43
Bituminous Coal Prices (Editorial). (Mar. 1939) 23
Considerations Affecting Selection of Pulverizers. By S. H. Reid. (Oct. 1938) 26
Evaporation Tests as a Measure of Coal Values. By G. B. Gould. (May 1939) 24
Grindability of Some American Coals. By H. F. Yancey and M. R. Geer. (Sept. 1938) 37
Judging Coal Values. By G. B. Gould. (Apr. 1939) 29
Purchase of Coal from Consumers' Viewpoint. By A. W. Thorson. (Nov. 1938) 33
Relation of Characteristics of Bituminous Coals to Their Use in Pulverized Firing. By E. R. Kaiser. (Nov. 1938) 41

Coal and Ash Handling Systems

Ash Disposal at the Schuylkill Station. (Mar. 1939) 24
Conveying Oil-Treated Coal. (June 1939) 35
Utilization of Pulverized Coal Ash. By A. W. Thorson and John S. Nelles. (Dec. 1938) 20

Feedwater and Boiler Water

Chromates for Corrosion Prevention in Standby Boilers. By Richard C. Ulmer and J. Murray Decker. (Sept. 1938) 31
Corrosion in Partially Dry Steam Generating Tubes. By F. G. Straub and E. E. Nelson. (Apr. 1939) 38
Deaerators and Their Applications. By E. S. Daugherty and C. E. Joos. (Feb. 1939) 31
pH and pOH Explained. By P. B. Place. (Mar. 1939) 33
Recirculation of Boiler Salines, The. By S. M. Sperry. (June 1939) 27
Some Fundamentals of Feedwater Treatment. (Jan. 1939) 31
Testing Boiler Waters for Embrittlement. By F. G. Straub and T. A. Bradbury. (Aug. 1938) 29
Treatment of Boiler Feedwater by Zeo-Karb Process. By Joseph D. Yoder. (May 1939) 35

Fuels (General)

Burning Oil-Refinery Fuels. By A. L. Wilson. (Mar. 1939) 27
Combination Oil and Pulverized Coal Burning. By Kingsley L. Martin. (Sept. 1938) 26
Fuel Bed Tests at Hell Gate Station. (Dec. 1938) 22
Stability of Colloidal Fuels. By C. H. S. Tupholme. (July 1938) 25

Furnaces

Furnace Photography. By A. A. Markson. (June 1939) 24
Modern Boiler Furnaces. By E. G. Bailey. (Dec. 1938) 18
Slag Bottom Furnaces. By W. E. Caldwell. (July 1938) 18
Slag Disposal (Editorial). (July 1938) 17

General Practice Developments and Trends

Developments in Central Station Power Plants. By A. D. Bailey. (Apr. 1939) 40
Industrial Power. By C. W. E. Clarke. (Dec. 1938) 16
(Jan. 1939) 21
Is America Ready for Forced-Circulation Boilers? By Alfred R. Smith. (Feb. 1939) 24
Operating Experiences with Large Turbine-Generators. (Sept. 1938) 30
Recent Practice in Power Piping. By Sabin Crocker. (Mar. 1939) 30

Heat Recovery

PAGE

Fouling and Corrosion of Air Heaters (E. E. I. Prime Movers Report). (Apr. 1939) 28
Selection of Economizers and Air Preheaters. By J. H. Sengstaken. (July 1938) 22

Installations

Delray Plant, Detroit Edison Co., Detroit, Mich.
High-Temperature Steam Experience at Detroit. By R. M. Van Duzer, Jr., and A. McCutchan. (Dec. 1938) 20
East St. Louis, Illinois, Plant, National Stock Yards, Armour & Co.
New Boiler Plant of Armour & Company. (May 1939) 32
Hell Gate Station, Consolidated Edison Co., New York, N. Y.
Fuel Bed Tests at Hell Gate Station. (Dec. 1938) 22
L Street Station, Boston Edison Company, Boston, Mass.
New Topping Unit for L Street Station, Boston. By George A. Orrok, Jr. (Nov. 1938) 35
Laguna Verde Generating Station, Cia Chilena Electricidad Limitada, Valparaiso, Chile
Laguna Verde Generating Station in Chile. By Louise Mann. (Apr. 1939) 24
Painesville, Ohio, Plant, Industrial Rayon Corporation
New Power Plant Serving Industrial Rayon Corporation. (Dec. 1938) 24
Port Washington Station, Wisconsin Electric Power Co.
Port Washington Still Leads in Performance (Editorial). (Jan. 1939) 15
Port Washington's Third Year of Outstanding Performance. (Jan. 1939) 16
Port Washington's Heat Rate. (Feb. 1939) 52
Riverside Station, United Power Manufacturing Co., Davenport, Iowa
Boiler Tests at Riverside Station. (Nov. 1938) 29
Rouge Plant, Ford Motor Company, Dearborn, Mich.
New Unit Started at Ford Plant. (May 1939) 40
Jacob Ruppert, Inc., New York, N. Y.
Modernized Brewery Power Plant. By William Schuler. (May 1939) 41
Schuylkill Station, Philadelphia Electric Company
Ash Disposal at the Schuylkill Station. By N. J. Walker. (Mar. 1939) 24
Springdale Station, West Penn Power Company, Pittsburgh, Pa.
Steam and Feedwater Controls at Springdale. (Aug. 1938) 16
A. E. Staley Manufacturing Co., Decatur, Ill.
Steam and Power Costs Reduced at A. E. Staley Plant. By John C. Kuhns. (Oct. 1938) 18
Toledo Refinery, The Pure Oil Company, Toledo, Ohio
Single Boiler Meets Refinery Steam Requirements. By D. S. Frank and J. M. Augustus. (Apr. 1939) 35

Marine Practice

High Pressure and Temperature in Marine Field. By L. M. Goldsmith. (Dec. 1938) 21
High Pressures in the Marine Field. (Editorial). (Dec. 1938) 15

Pulverized Fuel

Combination Oil and Pulverized Coal Burning. By Kingsley L. Martin. (Sept. 1938) 26
Considerations Affecting Selection of Pulverizers. By S. H. Reid. (Oct. 1938) 26
Relation of Characteristics of Bituminous Coals to Their Use in Pulverized Firing. By E. R. Kaiser. (Nov. 1938) 41

Research

Bituminous Coal Industry Considers Research. (Feb. 1939) 43
Chicago's Air Pollution Survey. (June 1939) 36
Corrosion in Partially Dry Steam Generating Tubes. By F. G. Straub and E. E. Nelson. (Apr. 1939) 38
Research and Unemployment (Editorial). (June 1939) 23

Steam Pressures, Temperatures and Cycles

Cracks in a High-Pressure Boiler Drum. By Prof. A. E. White. (Dec. 1938) 17
Design of High-Capacity Boilers. By John Van Brunt. (July 1938) 27
Developments in Central Station Power Plants. By A. D. Bailey. (Apr. 1939) 40
Developments in High-Pressure High-Temperature Valves. By V. T. Malcolm. (Nov. 1938) 24
High Pressure and Temperature in Marine Field. By L. M. Goldsmith. (Dec. 1938) 21
High-Pressure Steam Generators. By Henry Kreisinger. (Aug. 1938) 33
High Pressures in the Marine Field (Editorial). (Dec. 1938) 15
High-Temperature Steam Experience at Detroit. By R. M. Van Duzer, Jr. and A. McCutchan. (Dec. 1938) 20
Industrial Power. By C. W. E. Clarke. (Dec. 1938) 16
(Jan. 1939) 21
Recent Practice in Power Piping. By Sabin Crocker. (Mar. 1939) 30
Reheat Factors for Expansions of Superheated and Wet Steam. By Prof. C. G. Thatcher. (Dec. 1938) 21
Steam and Feedwater Controls at Springdale. (Aug. 1938) 16

Stokers

Fuel Bed Tests at Hell Gate Station. (Dec. 1938) 22

Turbine-Generators

	Page
Calculation of Steam-Turbine Reheat Factors. By R. B. Smith. (Dec. 1938)	21
Efficiency Comparisons of Turbine-Generators and Generating Stations. By James F. Field (Feb. 1939)	37
Load Distribution on Turbine-Generators. By Y. C. Lu (Jan. 1939)	28
Operating Experiences with Large Turbine-Generators (Sept. 1938)	30
Preferred Standards for Turbine-Generators (Dec. 1938)	23
Turbine Availability (May 1939)	28

Miscellaneous

	Page
Accidents among Utilities (Sept. 1938)	33
Central Station in One Man's Lifetime, The. By Geo. A. Orrok. (Sept. 1938)	34
Cylinder Oil in Condensed Steam. By A. F. Brewer. (Feb. 1939)	41
Determination of the Expansion Forces in Piping by Model Test, The. By H. W. Semar (Dec. 1938)	18
Digest of Power Papers at A.S.M.E. Annual Meeting. (Dec. 1938)	16
Electric Power Statistics (June 1939)	34
Influence of Steam-Flow Metering Equipment on Piping. By R. M. Van Duzer, Jr. (Dec. 1938)	19
Fabricating Alloy Steels. By A. R. McLain (Dec. 1938)	33
Legal Relationship of Employers and Employees. By Leo T. Parker (Sept. 1938)	39
Method for Determination of Reactions and Stresses in Expansion Pipe Bends, A. By F. Peiter and Dr. M. J. Fish. (Dec. 1938)	26
Recent Practice in Power Piping. By Sabin Crocker. (Mar. 1939)	30
Residual Stresses Due to Circumferential Welds in Pipes. By E. L. Eriksen and I. A. Wojtaszak (Oct. 1938)	33

Advertisers in This Issue

Air Preheater Corporation, The	20
American Blower Corporation	14 and 15
Armstrong Machine Works	13
Bayer Company, The	48
Buell Engineering Company, Inc.	Fourth Cover
Buromin Company, The	4 and 5
Clarage Fan Company	8
Combustion Engineering Company, Inc.	Second Cover, 10 and 11
De Laval Steam Turbine Company	48
Diamond Power Specialty Corporation.	Third Cover
Eagle-Picher Lead Company, The	16
Edward Valve & Mfg. Company, Inc., The	9
Ellison Draft Gage Company	44
Engineer Company, The	39 and 40
Hagan Corporation	4 and 5
Hall Laboratories, Inc.	4 and 5
Jenkins Bros.	17
Johns-Manville	7
Koppers Coal Company, The	6
Lummus Company, The	18
T. W. McNeill Engineering Equipment Company.	43
Northern Equipment Company	2
Permutit Company, The	22
Pittsburgh Coal Company	40
Poole Foundry & Machine Company	16
Refractory & Insulation Corporation	19
Reliance Gauge Column Company, The	40
Republic Flow Meters Company	12
Research Corporation	3
Steel and Tubes, Inc.	21
B. F. Sturtevant Company	Fourth Cover
Superheater Company, The	20
Vulcan Soot Blower Corporation	40
Western Precipitation Corporation	3
Yarnall-Waring Company	42

BAYER

BALANCED VALVE-IN-HEAD

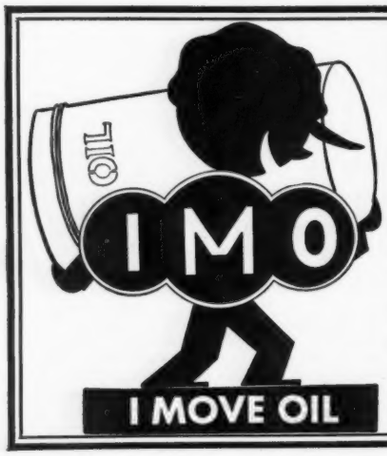
provides a valve action independent of element rotation—supplies full steam pressure necessary for full efficiency in reaching and cleaning all heating surfaces in present-day boilers.

CHRONILLOY ELEMENTS

made of austenitic high-temperature alloy have demonstrated longer low cost service life for Bayer Soot Cleaners. Write today for descriptive Bulletin No. 107.

THE BAYER COMPANY

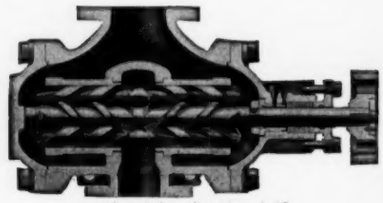
4028 CHOUTEAU AVENUE ST. LOUIS, MO.



SMALL *but* MIGHTY!

Small size and weight, with complete reliability, make the De Laval-IMO oil pump the favorite for doing a big job in a small place.

A vertical unit occupying less than 2 sq. ft. of floor space handles 500 g.p.m. of average lubricating oil.



Send for Catalog I-43

DE LAVAL STEAM TURBINE CO., TRENTON, N. J.

D E

ol.